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Forest Health Monitoring in New England: 1990 Annual Report

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Abstract

Reports the findings of the 1990 (first) Forest Health Monitoring field season. The objectives were to establish baseline conditions of New England forests for assessing attributes of forest health. Field visits were made to 263 sample plots across the six New England states, and measurements were taken on 206 plots determined to be forested. Results are detailed in 46 tables and summarized in text and charts. The representativeness of the sample, findings from tree-crown ratings, damage signs and symptoms, and bioindicator plants are discussed.

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Contents

Highlights

* Forest Health Monitoring (FHM), a national program, was implemented in New England in 1990.

* An extensive network of 263 FHM plots was established and measured.

* On 206 FHM plots classified as forested, 13,283 seedlings and saplings and 6,481 trees were sampled and marked for remeasurement.

* The proportion of FHM plots by land use and forest-type group and the distribution of trees by species were as expected from extensive forest surveys conducted in the early 1980's.

* Over all species, only 4 percent of upper canopy trees had moderate to severe crown dieback; American beech had the largest proportion (13 percent) of trees with moderate to severe dieback.

* Slightly more than 4 percent of upper canopy trees had moderate to severe foliage transparency; American beech had the largest proportion of trees with moderate to severe foliage transparency.

* Results of measurements of foliage discoloration, needle retention, and damage signs and symptoms suggest no unexplainable forest health concerns.

Introduction

New England's Forest Resource

Brooks et al. (1992) reviewed the status of New England's forest resources as of the last extensive forest surveys in the early 1980's. On the basis of data collected from 124,001 aerial photographic points and 4,731 forest survey plots, the six-state region was estimated to be more than 80 percent forested. With a total land area of over 40 million acres, this amounts to more than 32 million acres of forest land.

Forest land predominates throughout New England, with Maine most extensively forested and forest land in southern New England exceeding 60 percent of total land area. The dominance of forest land has been observed in each of the three regional forest surveys conducted since the early 1950's.

More than 85 percent of New England's forests are classified as one of four major forest-type groups: white pine, spruce-fir, oak-hickory, or northern hardwoods. Across New England, 82 tree species or species groups have been recorded on forest survey plots. The most common softwood species are balsam fir and red spruce; red maple is the most common hardwood species.

New England's forest resource has have been maturing: 46 percent is classified as sawtimber-size stands, which have the largest and presumably the oldest trees. The area of sawtimber-size stands has increased by 36 percent since the surveys of the 1970's. Concurrently, smaller poletimber- and seedling/sapling-size stands have decreased in area by 8 and 51 percent, respectively.

The predominance of forests in New England underscores their importance as a source of both commodity and amenity resources. Yet, these forests have been and continue to be exposed to a broad range of stressors, both natural and human caused. Natural stressors include weather extremes (e.g., wind, early snowfall, late freeze) and insects and pathogens. Land use change remains the human-caused stress of greatest impact.

The forests of New England are second and third regrowth subsequent to the original clearing at the time of the European settlement. Of recent concern is the subdivision of large forest tracts for residential use (Brooks and Birch 1988). Indirect human-caused stresses on New England forests are atmospheric pollution (e.g., ozone) and deposition (e.g., "acid rain", dry deposition). A major but not fully substantiated concern is global climate change caused by the generation of "greenhouse" gases.

Forest Health Monitoring in New England

The increased awareness of these stressors on the forest ecosystem has resulted in a corresponding increase in public concern about the "health and productivity of forests in certain regions of the United States" and in federal legislation mandating "such surveys as are necessary to monitor long-term trends in the health and productivity of domestic forest ecosystems" (Public Law 100-521). This mandate was implemented in the six New England states in 1990.

Forest Health Monitoring (FHM) in New England is a cooperative venture involving the USDA Forest Service, U.S. Environmental Protection Agency (EPA), and the state forestry agencies of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island. FHM was administered by an Executive Steering Committee composed of three senior USDA Forest Service personnel, two state foresters, a senior EPA employee, and an employee of Forestry Canada. This Committee appointed a Technical Committee of USDA Forest Service, state, and EPA personnel to design and implement FHM.

FHM is intended to be a long-term effort with major emphasis on detecting unexpected deviations from established baseline forest conditions. Specific objectives of FHM in New England are to:

1. Characterize the following forest conditions:
    a. Tree-growth rates.
    b. Tree vigor.
    c. Soil and site.
    d. Stand composition.
    e. Landscape characteristics.
2. Characterize the following potential forest stressors:
    a. Insects and pathogens.
    b. Climate (long term) and weather (short term).
    c. Atmospheric deposition and pollution.
    d. Other direct human activities.
3. Quantify changes in forest conditions and potential forest stressors.
4. Correlate changes in forest conditions with potential forest stressors.

Forest conditions are to be described by the measurement and reporting of data from several "health" indicators. Data elements have been divided into five indicator groups: growth, tree symptomatology, soil chemistry, foliar chemistry, and landscape characterization. Individual measurements support one or more indicators. Measurements will be made and indicators characterized on a periodic basis, annually for those that change most rapidly (e.g., foliar symptomatology) and on a four-year or longer cycle for those that change less rapidly (e.g., soil chemistry).

Methods

FHM Sample Plot Network

New England FHM is based on the annual remeasurement of an extensive network of permanent monitoring plots. The FHM sample plots were selected to correspond to a systematic grid sample identified by the EPA for its Environmental Monitoring and Assessment Program (EPA 1989, 1990). The statistical design "is characterized as a systematic, unstratified, equal probability area sample" that "maximizes spatial representation of all types of resources" (EPA 1989). The basic EMAP plot is a 40.6-km^2 (15.4-mi^2) hexagon. The hexagons are located approximately 27.4 km (17-mi) between center points, using a systematic grid. Collectively, the EMAP hexagons sample one-sixteenth of the total area. In New England, this proposed sampling design results in 263 sample hexagons (Table 1).

Table 1.--Number of aerial photographic points, Forest Health Monitoring (FHM) plots, forested FHM plots, and remeasured FHM plots, by state or region, New England, 1990

State or Region	Photographic Points	FHM Plots	Forested FHM Plots	Remeasured FHM Plots
	Number			
Maine	62,801	137	118	10
New Hampshire	15,950	37	33	7
Vermont	16,313	35	24	7
Southern New England	28,837	54	31	7
Total	124,001	263	206	31[1]

[1]Two plots were remeasured twice (one each in Massachusetts and New Hampshire).

The sample plots for FHM were selected from 124,00 points located on aerial photographs that are the first phase of the Northeastern Forest Inventory and Analysis (FIA) forest survey (Brooks et al., 1992). For each hexagon center point, the closest FIA aerial photo-interpretation point was identified and selected as the position of the FHM plot. If the selected plot was unavailable (e.g., landowner denial of access) the next closest photo point was selected as the FHM plot.

The plot design is a cluster of four 1/4-acre fixed-radius macroplots located in a triangular design (Fig. 1) with a total area of 1 acre. All trees 5.0 inches and larger in diameter at breast height (d.b.h.) are located, marked, and measured on 1/24th-acre fixed-radius subplots nested within each macroplot and using the same center point. Seedlings and saplings are measured on 1/300th-acre fixed-radius microplots offset 12 feet east of each subplot center. On or adjacent to the FHM plot, openings in the forest were searched for indicator plant species known to be sensitive to ozone, sulfur dioxide, and hydrogen fluoride.

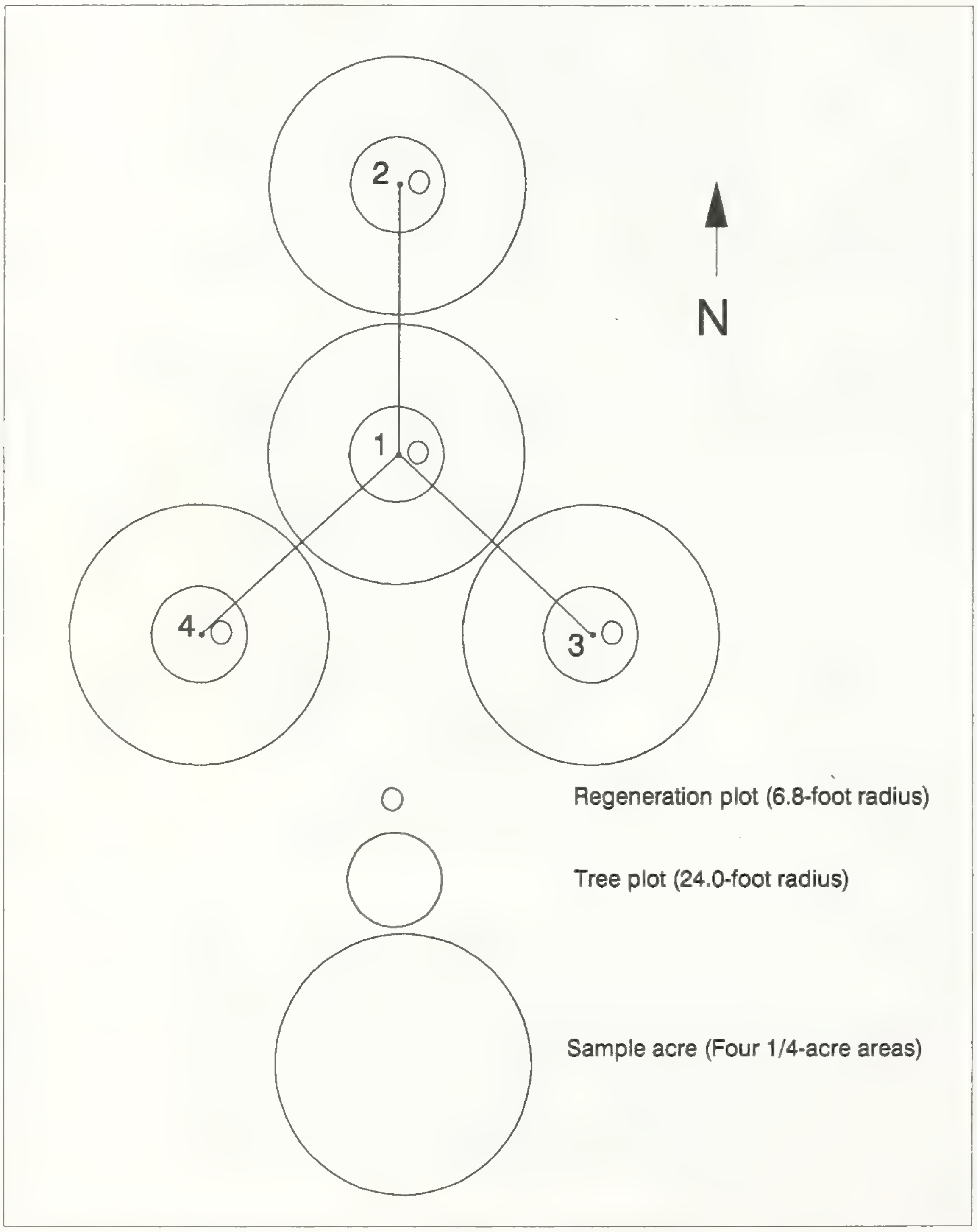

Figure 1.--Forest Health Monitoring (FHM) plot design (four-point fixed-plot cluster), New England, 1990. Distance between points is 120 feet.

At all plots, land use was classified at the center point of subplot No. 1 (Appendix, Table 9). In 1990, for those plots determined to be nonforested, only land use was recorded. For forested plots, data were collected on the political, geographic, and topographic location of the plot; lesser vegetation; tree diameter, crown position, crown rating, and damage; and indicator plants (Table 2). In 1990, 206 FHM plots were classified as forested (Table 1).

Table 2.--List of field data elements, Forest Health Monitoring, New England, 1990

Sample Location Data

State
County
Plot number
Land use
Elevation
Date of survey
Field crew staff

Plot Data

Percent cover by moss, ferns, herbaceous, and shrubs
Percent slope
Aspect
Terrain position
Microrelief
Landform
Disturbance
Uniformity
Forest type

Tree Data

Species
Distance and azimuth to plot center
Diameter at breast height
Crown class
Percent live crown, dieback, transparency, discoloration
Needle retention
Signs/symptoms, location, and probable cause

Indicator Plant Data

Indicator plot location
Species
Indicator type (pollutant)
Total stem count
Count with symptoms

Detailed procedures for field data collection were specified in a data-collection manual (Dwire et al. 1990). Field crews from each participating state were trained and evaluated in field-data collection during a weeklong training session.

Data Analysis

Most of the field data were collected with portable data recorders. Data were uploaded to microcomputers and transmitted to the USDA Forest Service via floppy disk. The data were then uploaded to the Forest Service's mainframe computer system. Data were edited and processed using FINSYS, a forest inventory processing system. Data summaries were compiled in the tabular format presented in this publication. Procedures for the estimation of sampling error are provided in the Appendix. Comparisons between the FHM sample and the New England forest resource as characterized by FIA were made by a chi-square goodness of fit test of how much a sample distribution deviates from a theoretical distribution (Zar 1974).

Quality Assurance/Quality Control

Quality Assurance (QA) specifies operating procedures and measurement quality objectives.Quality Control (QC) is accomplished by the remeasurement of a subsample of plots to determine the compliance with QA specifications, and by audit checks of field crews in the process of measuring plots. QC plots were remeasured by an independent field crew.

Quality Assurance standards were specified in the data-collection manual and explained during training. Data quality was determined by the remeasurement of 31 plots (Table 1) distributed so that all field crews were checked at least once. QA/QC compliance is reported fully in the Appendix.

Results and Discussion

Comparison of Sample with New England's Forests

The 263 FHM sample plots do characterize the New England forest resource, as reported byFIA (Brooks et al., 1992). On the basis of FIA reports, 213 of the 263 plots were predicted to be forested. After field measurement, 206 plots were classified as forested (Table 1). The chi-square statistic for the comparison of these two distributions (X^2 = 1.123 [with Yates correction for 1 d.f.], d.f. = 1, 0.25 < P < 0.5) is not significant. The distribution of the 206 forested plots does not differ significantly from that expected from FIA for either forest-type group (X^2 = 1.98, d.f. = 4, 0.5 < P < 0.75) or stand-size class (X^2 = 1.142, d.f. = 2, 0.5 < P < 0.75).

All tree-level results are from 204 of the 206 forested FHM plots. Two plots were tallied late in the year due to logistical problems; the tree data from these plots are not complete and are not included in this report.

In all, 63 species, 14 softwoods and 49 hardwoods, were tallied (Appendix Table 11); 55 additional sample trees were not identified by species. This is fewer than the 76 species, 16 softwoods and 60 hardwoods, tallied on FIA plots (Brooks et al., 1992). The distribution of poletimber-size and larger trees on the forested plots does not differ significantly by species from that expected using FIA data (X^2 = 14.013, d.f. = 11, 0.10 < P < 0.25). While the species distribution is not significantly different from expected, two species do show large deviations from expected values, balsam fir (observed average density = 19 trees/acre, expected = 30.7) and white pine (observed = 21.1 trees/acre, expected = 12.7) (Fig. 2).

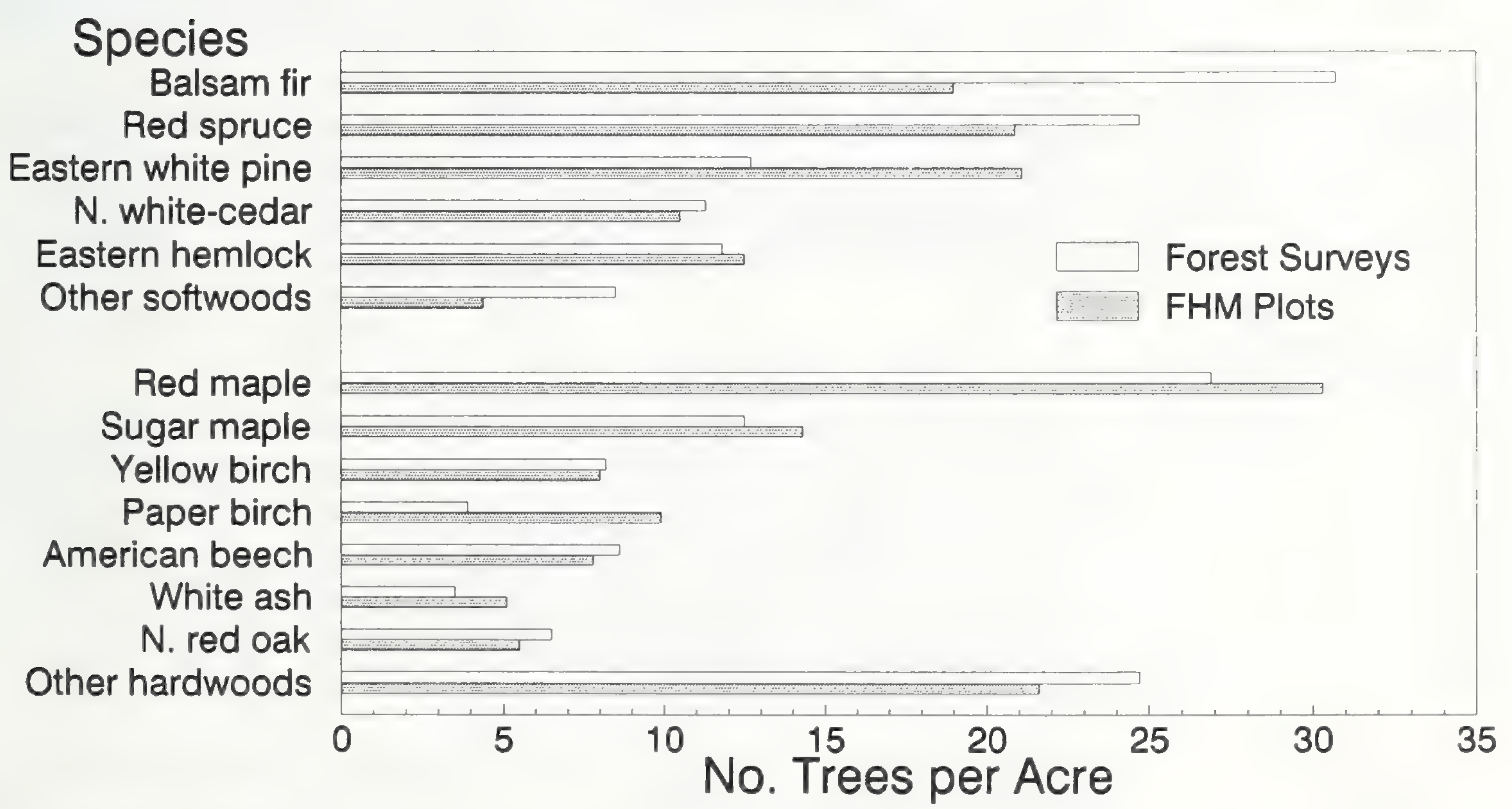

Figure 2.--Average number of trees per acre by species or species group, forest surveys and FHM plots, New England.

The low representation of balsam fir may be due to mortality attributed to the eastern spruce budworm (*Choristoneura fumiferana* Clemens) and to increased salvage cutting in response to budworm infestation. Average density of standing-dead balsam fir was 4 trees/acre in the early 1980's according to FIA surveys for all New England forest land and 6.7 trees/acre for the FHM plots. On forest land classified as spruce-fir, the average density of standing-dead balsam fir was 10.3 trees/acre as reported by FIA and 19.4 trees/acre on FHM plots. Conversely, the average density of seedling/sapling-size balsam fir, the regeneration, was 1,917 trees/acre on spruce-fir forests as reported in FIA surveys in the 1980's, and 3,005 trees/acre on FHM plots in 1990.

This increase in dead balsam fir follows a pattern reported by the Maine Forest Service (1988) as observed in the 1986 midcycle resurvey of the spruce-fir forests of Maine. At that time, this change in tree numbers and volume was ascribed to spruce budworm defoliation. The midcycle resurvey report also noted that the number of spruce trees declined between the 1980 FIA survey and 1986, and that removals (i.e, tree harvests) exceeded net growth. The 1990 FHM survey sampled fewer red spruce than expected from FIA data. This may be due to the harvest of growing-stock trees in response to budworm damage.

Eastern white pine was sampled at greater than expected levels in both the white pine and northern hardwoods forest-type groups and at less than expected levels in spruce-fir and oak-hickory groups. Average density of standing-dead white pine 5.0 inches and larger in d.b.h. increased from 0.6 to 1.1 trees per acre between the FIA and FHM surveys. There is no clear explanation of this result.

The distribution of standing-dead trees by species is all but identical between FHM and that predicted from FIA surveys ($X^2 = 3.105$, d.f. = 11, $0.975 < P < 0.99$).

The distribution of trees 1.0 to 20.9 inches in d.b.h. on FHM plots differs significantly from that expected from FIA surveys for both softwood ($X^2 = 23.396$, d.f. = 12, $0.025 < P < 0.001$) and hardwoods ($X^2 = 33.933$, d.f. = 12, $P < 0.001$) species. FHM sampled fewer softwoods 3.0 to 8.9 inches in d.b.h. and more hardwoods saplings than expected (Fig. 3).

Tree-Crown Ratings

Each sampled tree was rated for three (hardwood) or four (softwood) characteristics: crowndieback, foliage transparency, foliage discoloration, and needle retention. These ratings were recorded in 5-percent classes but are grouped in 10-percent classes for this report. The ratings are reported only for trees whose crowns are directly exposed to the atmosphere (i.e., open grown, dominant, or codominant), or upper canopy trees. For all forested plots, upper canopy trees account for 68.7 percent of all sampled trees (Appendix Table 16).

A complete description of crown rating procedures is provided in the FHM Field Manual (Dwire et al. 1990).

<u>Crown dieback</u>. Dieback is branch mortality beginning at the terminal portion of the branch and proceeding inward toward the trunk. This pattern of mortality is an indicator of premature branch death. Whole dead branches in the upper exposed tree crown

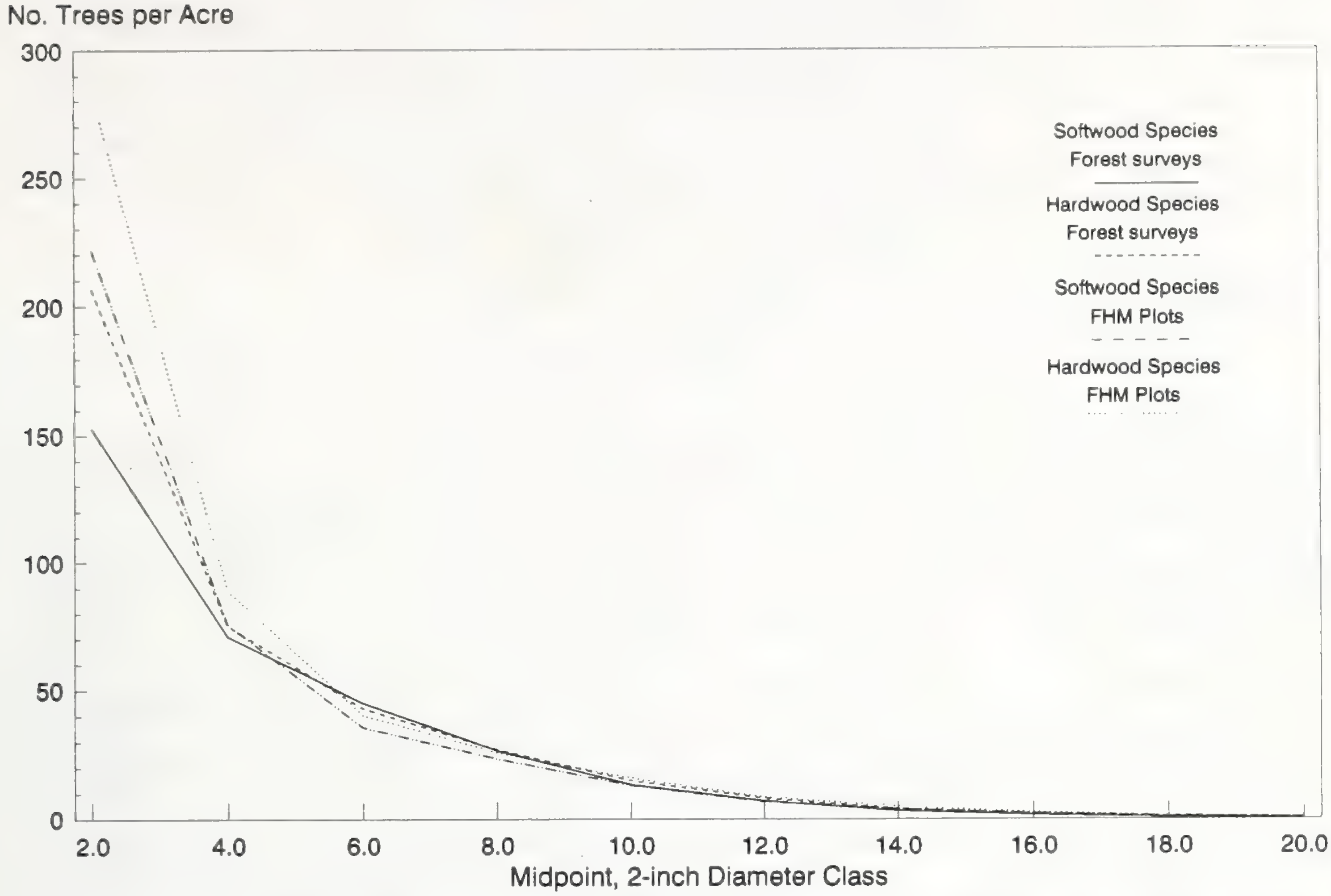

Figure 3.--Average number of trees per acre by 2-inch diameter class and species group, forest surveys and FHM plots, New England.

are assumed to have died from the terminus inward (i.e., dieback). Dead branches in the lower crown are assumed to have died of suppression or natural senescence and are not included in this measurement. For this report, dieback-severity classes are defined as: none to trace, 0 to 5 percent; light, 6 to 20 percent; moderate, 21 to 50 percent; severe, more than 50 percent.

Most of the major softwood species had no or light crown dieback (Fig. 4). Major softwoods with a relatively large proportion of sample trees with moderate or severe dieback were hemlock and northern white cedar. Of 142 eastern hemlock located widely on four sample plots in three states, five trees had moderate or severe dieback, and damage sign and symptom codes were recorded for three of these trees. Of 198 dominant and codominant cedars, 10 trees had moderate or severe dieback. These 10 trees were on eight sample plots in four counties in Maine. Of these trees, seven also had secondary signs or symptoms, generally large open wounds that probably would contribute to their decline and eventual death.

Hardwoods had more crown dieback than softwoods, though less than 10 percent of most of the major species had dieback that was moderate to severe. Of the major hardwood species, northern red oak had the largest proportion of trees with no to light dieback (Fig. 4) and only American beech had more than 10 percent of sample trees with moderate to severe dieback. Red maple had the second highest proportion of sample trees with moderate to severe dieback. Among the minor species (i.e., fewer than 100 trees in the sample), black ash and elm had high proportions of trees with moderate to severe dieback.

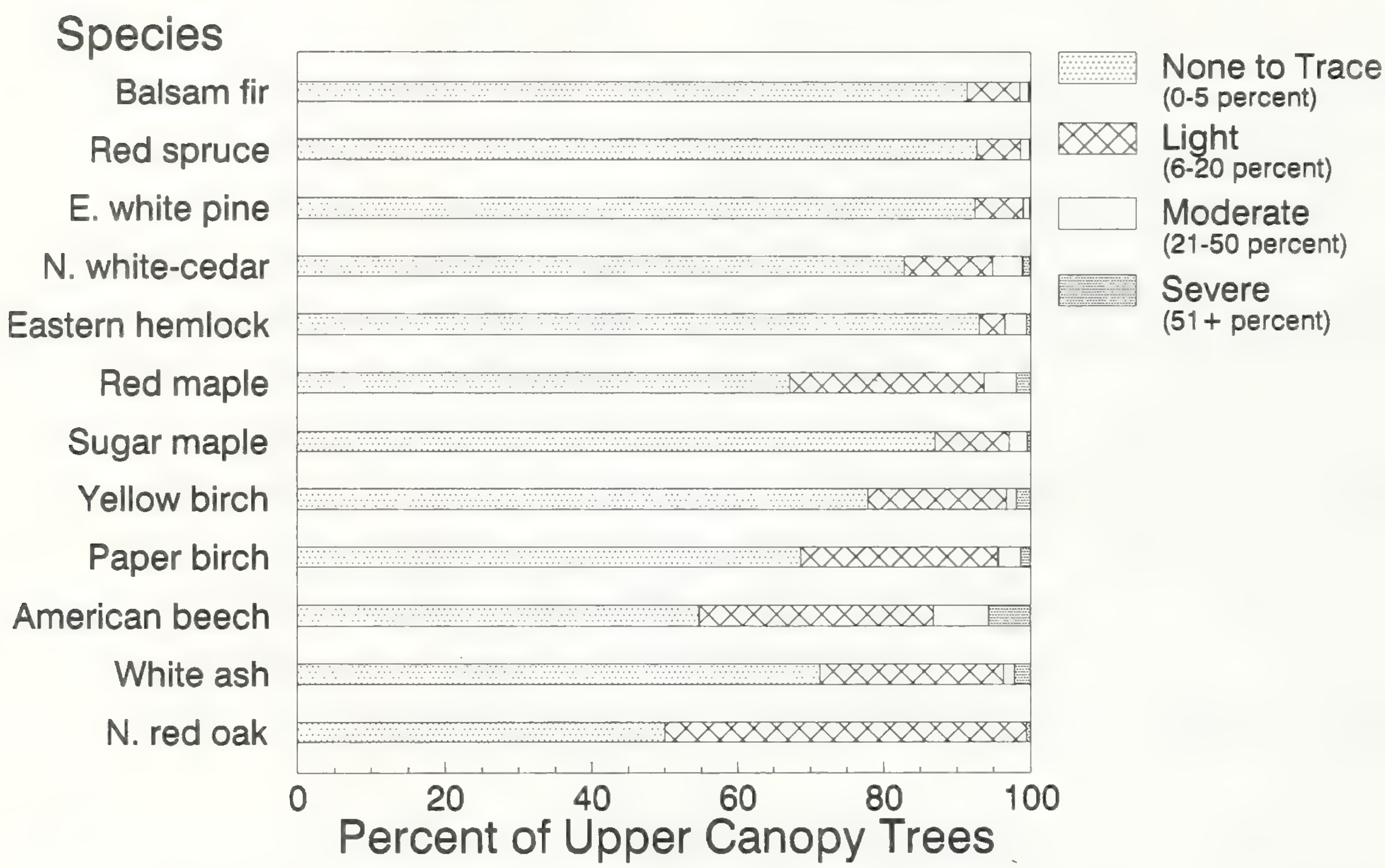

Figure 4.--Distribution of upper canopy trees by crown-dieback class and major species, FHM plots, New England, 1990.

Twenty-one dominant and codominant American beech with moderate to severe dieback were recorded on eight sample plots in five Maine counties, and two plots in two counties in New Hampshire. These trees were from a total of 159 open-grown, dominant, and codominant beech. Of the 21 trees, 14 also had secondary signs or symptoms, generally open wounds. The beech bark disease complex (beech scale [*Crytococcus fagisuga* Lindinger] and fungi [*Nectria coccinea* var. *faginata* Loh., Wats., and Ay.]) is an obvious consideration.

Moderate to severe dieback was recorded in 50 of 799 upper canopy red maple trees that were distributed broadly across 27 sample plots in five of the six New England states. Of these 50 trees, 38 also had damage signs or symptoms, generally wounds, cracks, and holes.

Foliage transparency. Foliage transparency refers to the amount of skylight visible through the foliated portion of a tree crown. It is intended as a measure of foliage density for the crown as a whole, accounting for foliage reductions in either size or number due to insects, pathogens, or environmental stress. The degree of transparency differs by species and depends on branching and leafing patterns. Transparency serves as an estimate of defoliation.

Of the full sample of trees, nearly one-half were in the 11 to 20 percent transparency class; an additional 33 percent of the sample had transparency of 1 to 10 percent, and 14 percent had transparency of 21 to 30 percent (Appendix Table 37). Trees with less than 5 percent transparency are uncommon, transparency of less than 30 percent being is considered normal for all trees. Severe transparency (more than 50 percent) indicates foliage thinning in response to stress and is considered abnormal.

Severe foliage transparency on softwood species was recorded only for northern white-cedar (Fig. 5). Among the major softwoods, moderate transparency was highest for northern white-cedar, eastern white pine, and eastern hemlock. Because remeasurements of softwoods indicated much variability between raters, the high incidence of moderate transparency for northern white-cedar and eastern white pine should be investigated as a potential measurement problem.

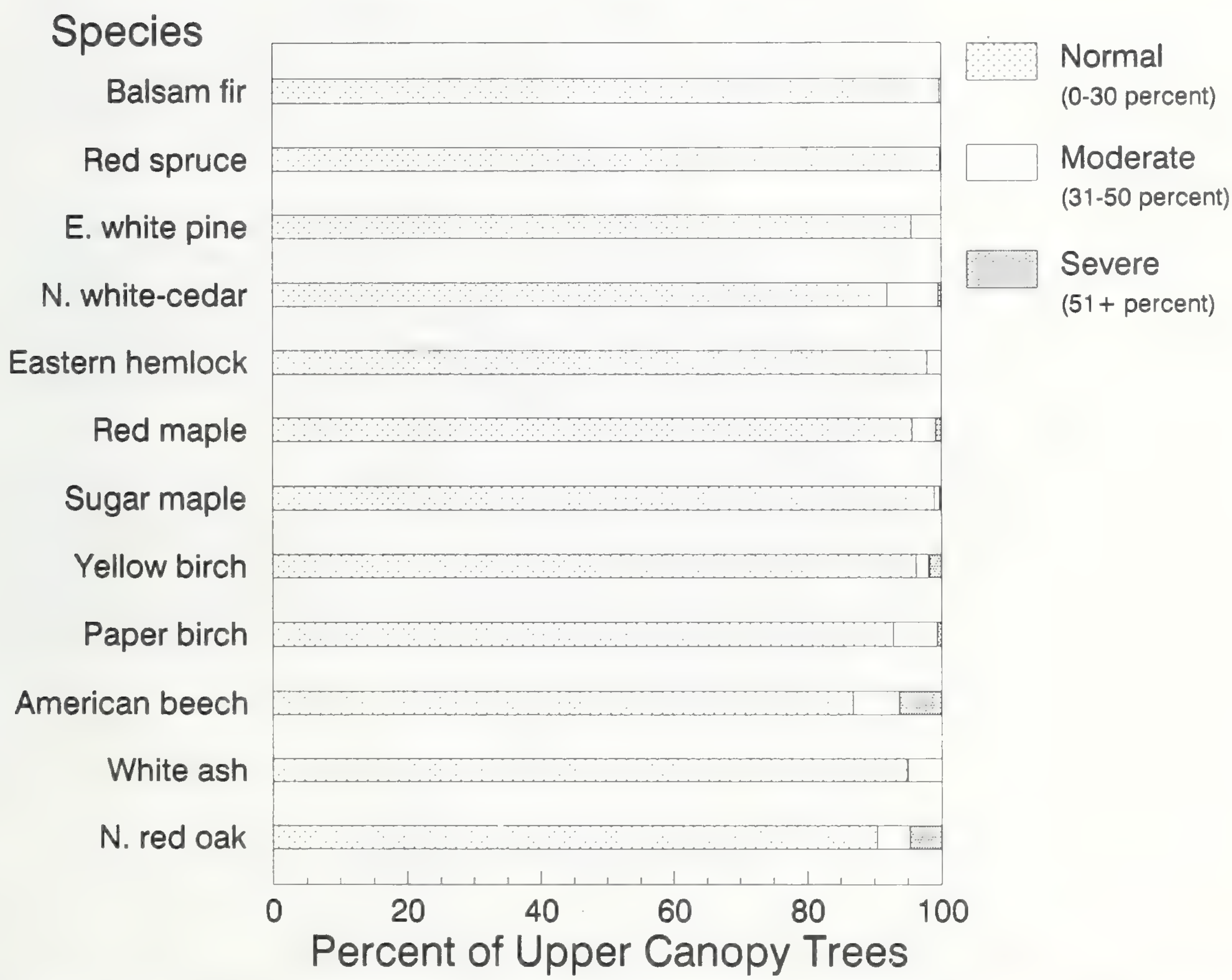

Figure 5.--Distribution of upper canopy trees by foliage-transparancy class and major species, FHM plots, New England, 1990.

Foliage transparency was higher for hardwoods than for softwoods. Severe levels of transparency were recorded most frequently for American beech and northern red oak; severe transparency was least frequent on white ash and sugar maple. Among the less common hardwood species, elm had the highest proportion of trees with severe transparency, but the sample was small (Appendix Table 35).

The severe transparency observed for American beech probably reflects decline from beech bark disease; for northern red oak, gypsy moth (*Lymantria dispar* L.) defoliation; and for elm, Dutch elm disease *Ophiostoma ulmi* [Buism.] Nannf.). Of 159 upper canopy American beech, 21 had moderate to severe transparency. Of these, 11 also had damage signs or symptoms and 12 had moderate to severe dieback. For northern red oak, 16 of 166 upper canopy trees had moderate to severe transparency, but only 7 of these also had damage signs or symptoms and only 1 was recorded as having moderate dieback.

Discoloration. Foliage is considered discolored when the overall appearance is noticeably yellow, red, or brown. More than 50 percent of a leaf or needle must be discolored for the discoloration to be tallied. Trace amounts of discoloration are expected for any tree.

Foliage discoloration greater than 20 percent was rare in open-grown, dominant, and codominant trees. This level of discoloration was recorded only for four American beech, three red maples, three northern red oak, two eastern white pine, and one balsam fir, and one aspen (Appendix Table 41). There was no indication of health concerns expressed as early or abnormal discoloration.

Needle rentention. Needle retention, the number of years that needles are retained by a tree, is an indicator of tree vigor. On the basis of expected needle retention, the longer a tree retains needles, the more vigorous its growth. Needle retention is measured as the age of the oldest internode with more than 25 percent of the needles present. Usually, spruce are expected to carry about nine years of needles versus four years for balsam fir and two to three years for pine species.

Results from 1990 FHM needle retention surveys indicate that balsam fir typically carried five to six years of needles, red spruce, six or more years, and eastern white pine two years (Fig. 6). These results and QA remeasurement indicate that this measure requires better documentation and training before the data can be considered reliable. This measurement might require an "in hand" assessment rather than a visual assessment using binoculars, as was conducted by FHM field staff.

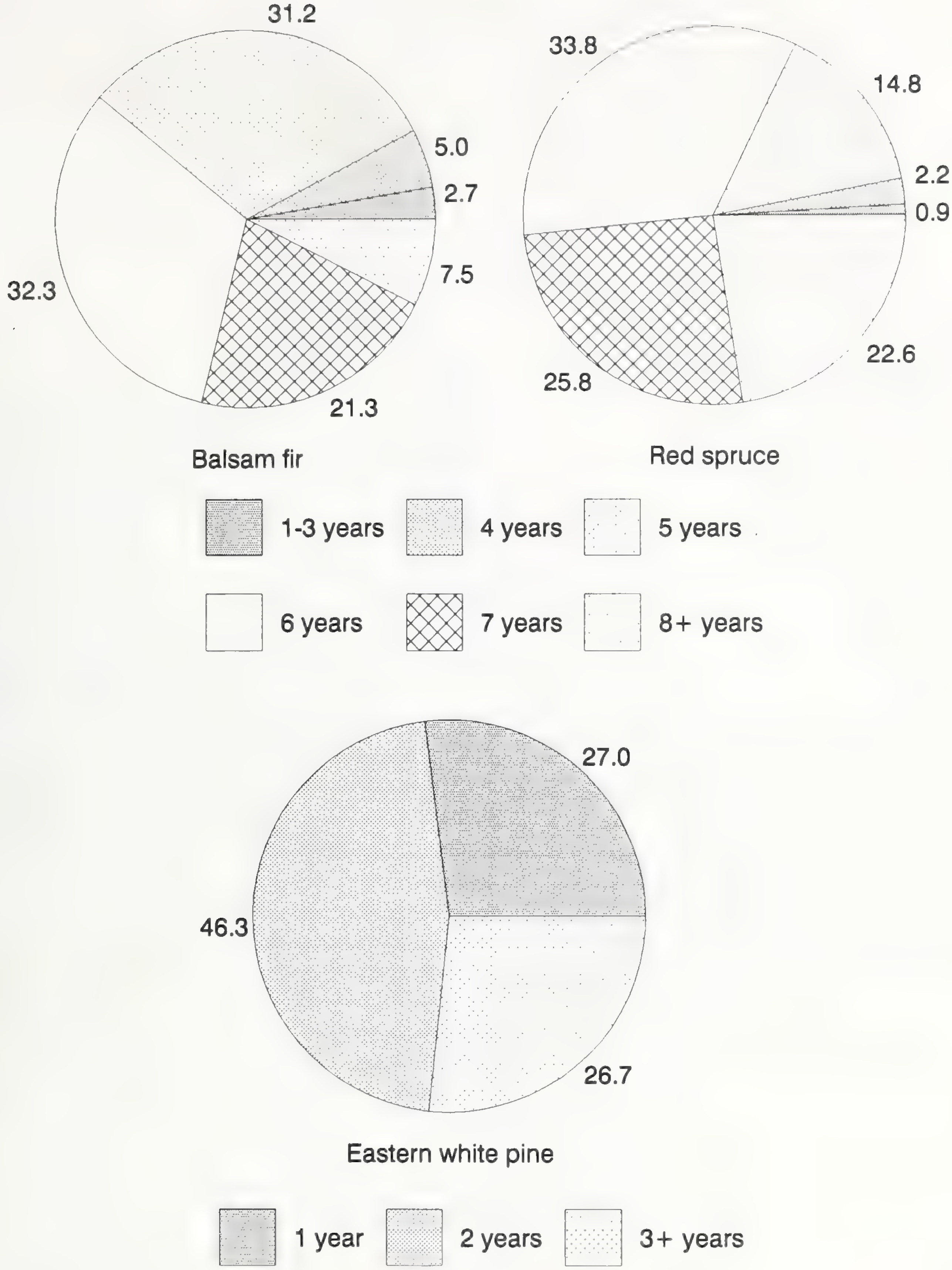

Figure 6.--Distribution (in percent) of upper canopy trees by species and years of needle retention, FHM plots, New England, 1990.

Damage Signs and Symptoms

Damage signs or symptoms were recorded for all trees 5.0 inches and larger in d.b.h. Many trees had more than one sign or symptom. Among the major softwoods, the percentage of trees without signs or symptoms ranged from 66.8 for northern white-cedar to 83.3 for red spruce (Fig. 7). The major sign or symptom observed on softwoods was large open wounds on northern white-cedar (17.3 percent of sample trees), eastern hemlock (7.7 percent), red spruce (7.4 percent), and balsam fir (6.7 percent). Resinosis was the second most common sign or symptom, recorded most often on eastern white pine (5.4 percent) and red spruce (3.4 percent). Other major signs and symptoms were cracks on balsam fir (9.6 percent), small holes on eastern hemlock (6.8 percent), and crooks and sweeps on eastern white pine (6.1 percent) (Appendix Table 48).

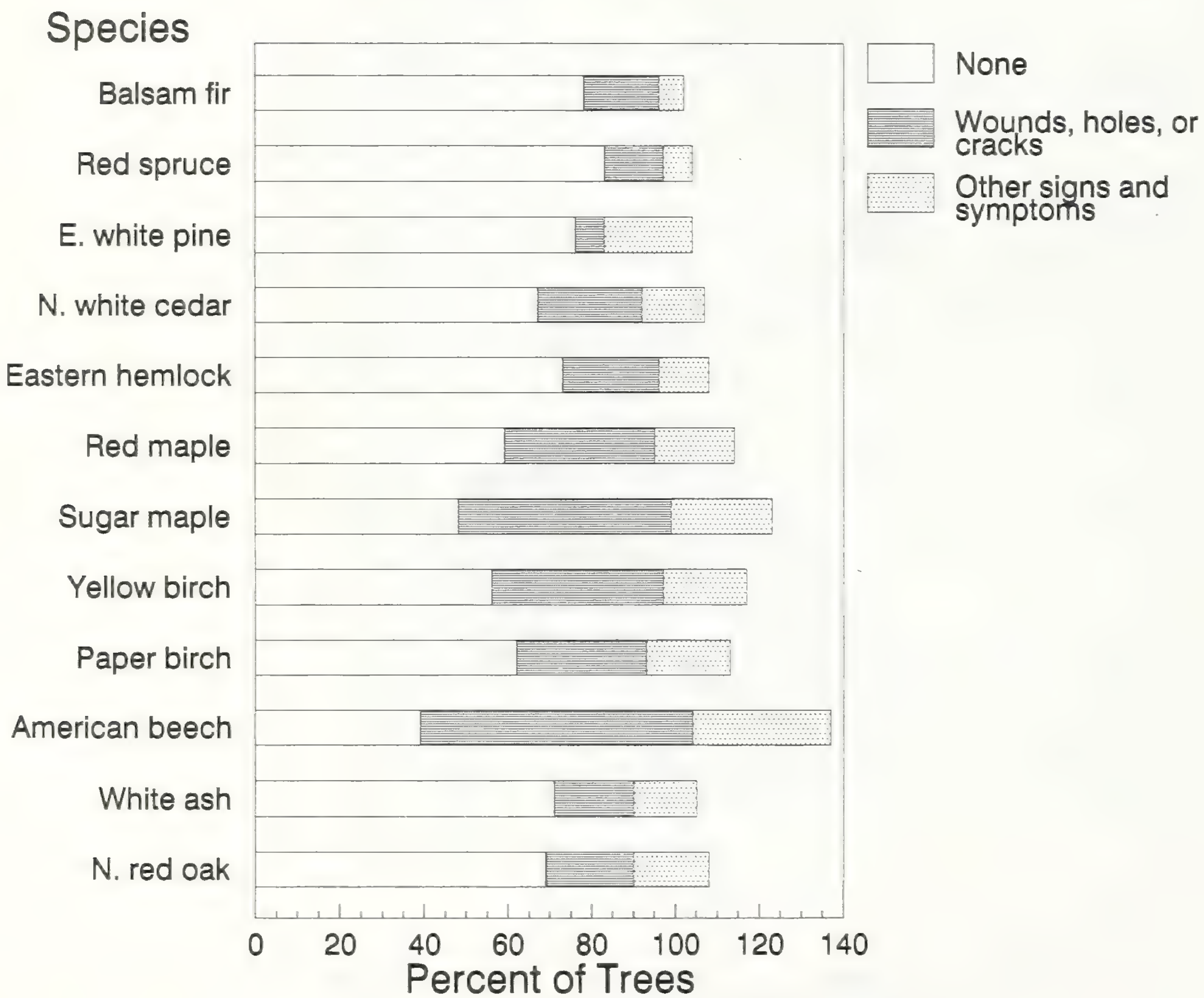

Figure 7.--Distribution of trees by damage signs and symptoms and major species, FHM plots, New England, 1990 (may exceed 100 percent due to occurrence of multiple signs and/or symptoms.

The percentage of major hardwoods with no recorded damage signs or symptoms was lower than for softwoods, ranging from 39 for American beech to 68.6 for northern red oak (Fig. 7). The most common sign or symptom was large open wounds recorded on American beech (43.6 percent of sample trees), sugar maple (30.3 percent), yellow birch (23.2 percent), paper birch (22.5 percent), white ash (14.9 percent), and northern red oak (7.4 percent). Cracks on the trunk, the next most common sign or symptom on hardwoods, were recorded on sugar maple (14.6 percent), yellow birch (9.2 percent), northern red oak (8.5 percent), and red maple (8.1 percent). Other major signs and symptoms were small holes on American beech (11.1 percent) and crooks and sweeps on northern red oak (7.4 percent) and white ash (4 percent) (Appendix Table 48).

On eastern white pine, the crooks and sweeps most likely are the result of past damage from the white pine weevil (*Pissodes strobi* [Peck]), while the resinosis and open wounds might be caused by white pine blister rust (*Cronartium ribicola* Fisch.). The 24 red spruce, 3 percent of the sample, with resinosis/bleeding symptoms probably are infected with *Phellinus pini* (Thore:Ff) P.Karst. The red pine sample included a high proportion of trees with small holes, but the sample was small and can disregarded. However, a large percentage (17.3) of northern white-cedar had open wounds which should be examined by forest health specialists to assess the probable cause. The probable causes of the signs and symptoms of the other softwoods are not known. Since the percentages of trees affected generally are low, further investigation does not seem warranted. The long-term effect of damage on tree health will be assessed by the periodic remeasurement of all sample trees.

Bioindicator Plants

Gaseous air pollutants such as ozone, sulfur dioxide, and hydrogen fluoride produce a variety offoliar symptoms on some forest vegetation. Foliar symptoms on some species are useful indicators of possible air pollution stress (Table 3). Bioindicator species were used to detect the presence of high levels of ozone, sulfur dioxide, or hydrogen fluoride on the NHM plots. The assumption is that if levels were high enough to cause visible injury on bioindicators, they may have been high enough to affect the physiology, growth, or vigor of other plant species on the FHM plot. The presence of symptoms of air pollution injury on bioindicator plant species was recorded when observed.

Table 3.--Common and scientific names of bioindicator plant species for ozone, sulfur dioxide, and hydrogen fluoride, Forest Health Monitoring, New England, 1990

Bioindicator plant species	Ozone	Sulfur Dioxide	Hydrogen Floride
	Herbaceous Plants		
Milkweed (*Asclepias syriaca*)	X		
Wild grape (*Vitis* sp.)	X		X
Poison ivy (*Rhus toxicodendron*)	X		
Blackberry (*Rubus alleghaniensis*)	X		
Giant ragweed (*Ambrosia trifida*)		X	
Bracken fern (*Pteridium aquilinum*)		X	
Blackberry/raspberry (*Rubus* sp.)		X	
Blueberry (*Vaccinum* sp.)			X
	Deciduous Trees		
White ash (*Fraxinus americana)*	X		X
Black cherry (*Prunus serotina*)	X		
Yellow-poplar (*Liriodendron tulipifera*)	X		
Sweetgum (*Liquidambar styraciflua*)	X		
Trembling aspen (*Populus tremuloides*)		X	
Green ash (*F. pennsylvanica*)		X	
White birch (*Betula pendula*)		X	
Birch (*Betula* sp.)			X
Maple (*Acer* sp.)			X
	Conifer Trees		
Eastern white pine (*Pinus strobus*)	X		
Pine (*Pinus* sp.)			X
Spruce (*Picea* sp.)			X

One or more bioindicator plant species for one or more air pollutants were recorded on 193 FHM plots (Appendix Table 49). Ozone symptoms were recorded on 18 plots and symptoms of sulfur dioxide 6 plots. No symptoms of damage from hydrogen fluoride were recorded. The occurrence of foliar symptoms due to gaseous pollutants depends on the timing of both pollutant exposure and the plot visit: if the plot was sampled prior to a critical pollutant exposure, no symptoms would have been recorded when, in fact, the plot would have been symptomatic at a later date.

Forest Stressors

Major Forest Pests in New England 1990

This section discusses the major forest insect and disease problems and declines that are now or thatmay become significant in the near future in New England. The information that follows was obtained from state pest conditions reports and USDA Forest Service forest health protection survey reports that were incorporated into the 1990 forest health report for New England and New York (Peterson and Cox 1991).

Hardwood insect pests. The oak resource continues to be defoliated extensively by the gypsy moth (Fig. 8). In 1990, more than 700,000 acres of defoliation, occurring in virtually all of the hardwood forest types, was reported in New England. Defoliation increased dramatically over 1989 levels, particularly in Maine, Vermont, New Hampshire, Massachusetts, and Connecticut. In many areas, larval mortality has been significant due to fungal (*Entomophaga maimaiga* Humber, Shimazu & Soper) or viral infection, though populations have remained high or have continued to expand. Rhode Island has reported low populations and no significant defoliation during the last two years.

Other hardwood defoliators were at low levels in most of the region. The eastern tent caterpillar (*Malacosoma americanum* [Fabricius]) and the forest tent caterpillar (*Malacosoma disstria* Hubner) are found in a variety of northern hardwood forest types. The eastern tent caterpillar was found in Vermont and into western Massachusetts on black cherry, apple, other ornamentals, and hardwoods. Populations of the forest tent caterpillar declined in Maine and Vermont. The oak leaftier (*Croesia semipurpurana* [Kearfott]) affects the oak component of the oak-hickory and oak-pine forests. Also, populations of the oak leaftier in Vermont, New Hampshire, and Massachusetts have diminished from recent outbreak levels (Fig. 9).

The pear thrips (*Taeniothrips inconsequens* [Uzel]), which is found in the northern hardwood forest type and which primarily attacks sugar maple, was at a lower level than in recent years in most areas; however, damage from this the insect increased in Vermont (Fig. 9). Damage was heaviest in the northern portion of the state as thin crowns were apparent where trees did not refoliate. The affected trees became more susceptible to additional damage from anthracnose and other maple defoliators. Populations of the saddled prominent (*Heterocampa guttivitta* [Walker]) increased in Vermont and Massachusetts and caused defoliation in sugar maple, beech, yellow birch, and black cherry in scattered locations (Fig. 9).

Other insects that caused defoliation at throughout New England, include the browntail moth (*Euproctis chrysorrhoea* L.), which attacked several species of ornamentals and shade trees in coastal Maine and Massachusetts; the Bruce spanworm (*Operophtera bruceata* [Hulst]), which affected northern hardwoods in Vermont and Maine; the cherry scallop shell moth (*Hydria prunivorata* Ferguson), whcih caused noticable defoliation of various cherry species in southern Vermont, and New Hampshire, and western Massachusetts; and the fall cankerworm (*Alsophila pometaria* [Harris]), which defoliated northern hardwoods in southeastern Massachusetts.

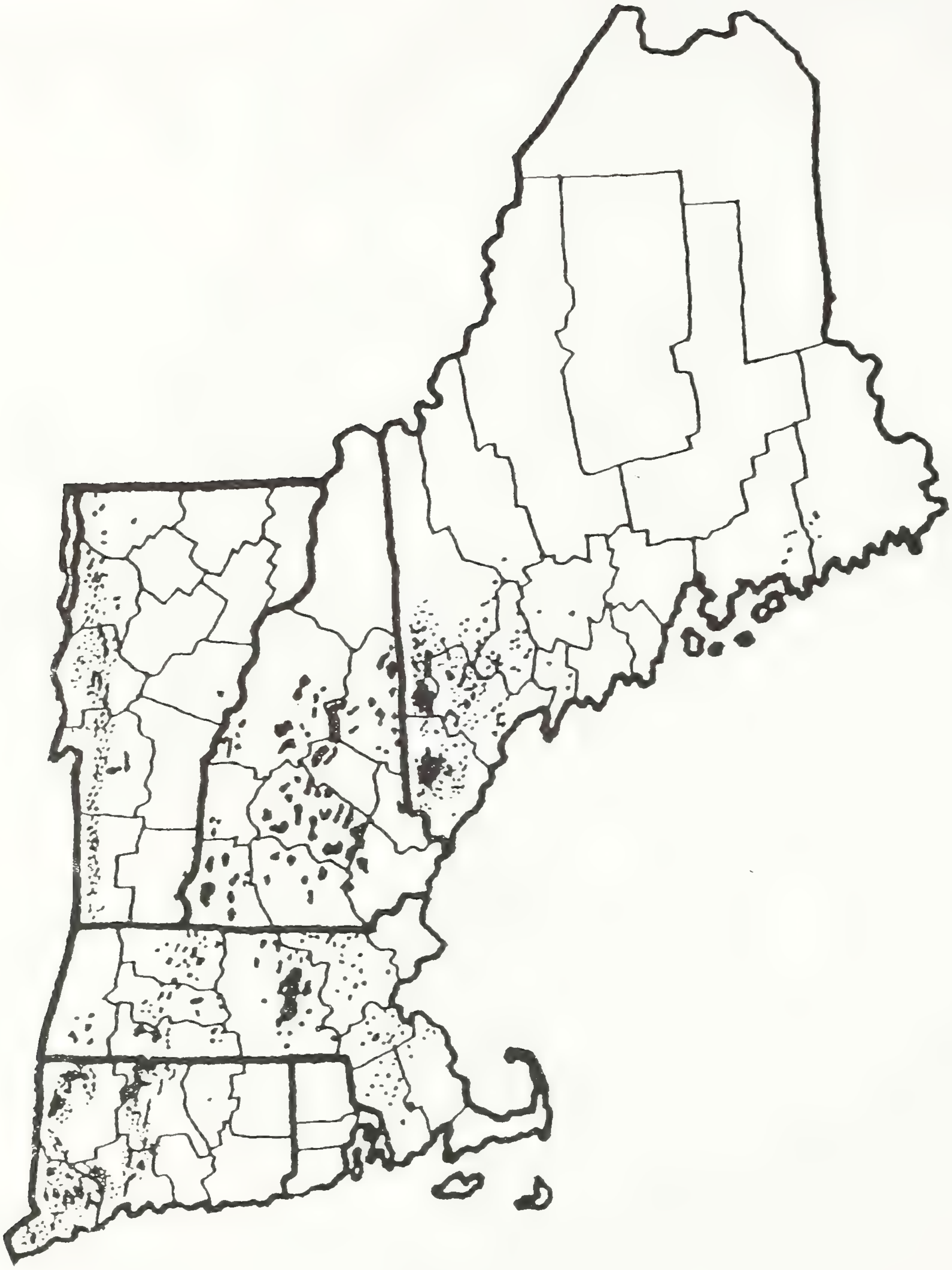

Figure 8.--Gypsy moth defoliation by county and state, New England, 1990.

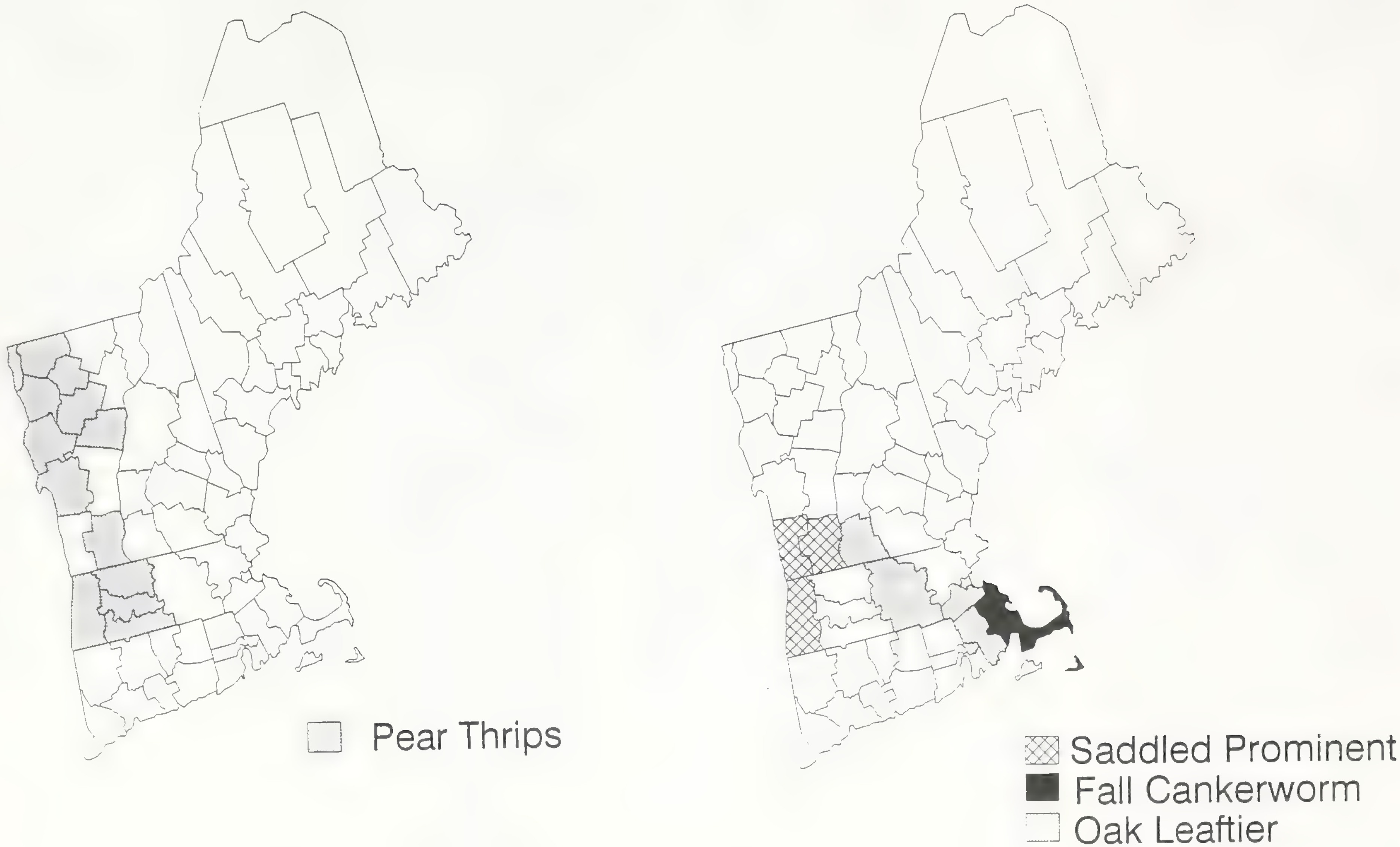

Figure 9.--Occurrence of various forest insect pests by county and state, New England, 1990.

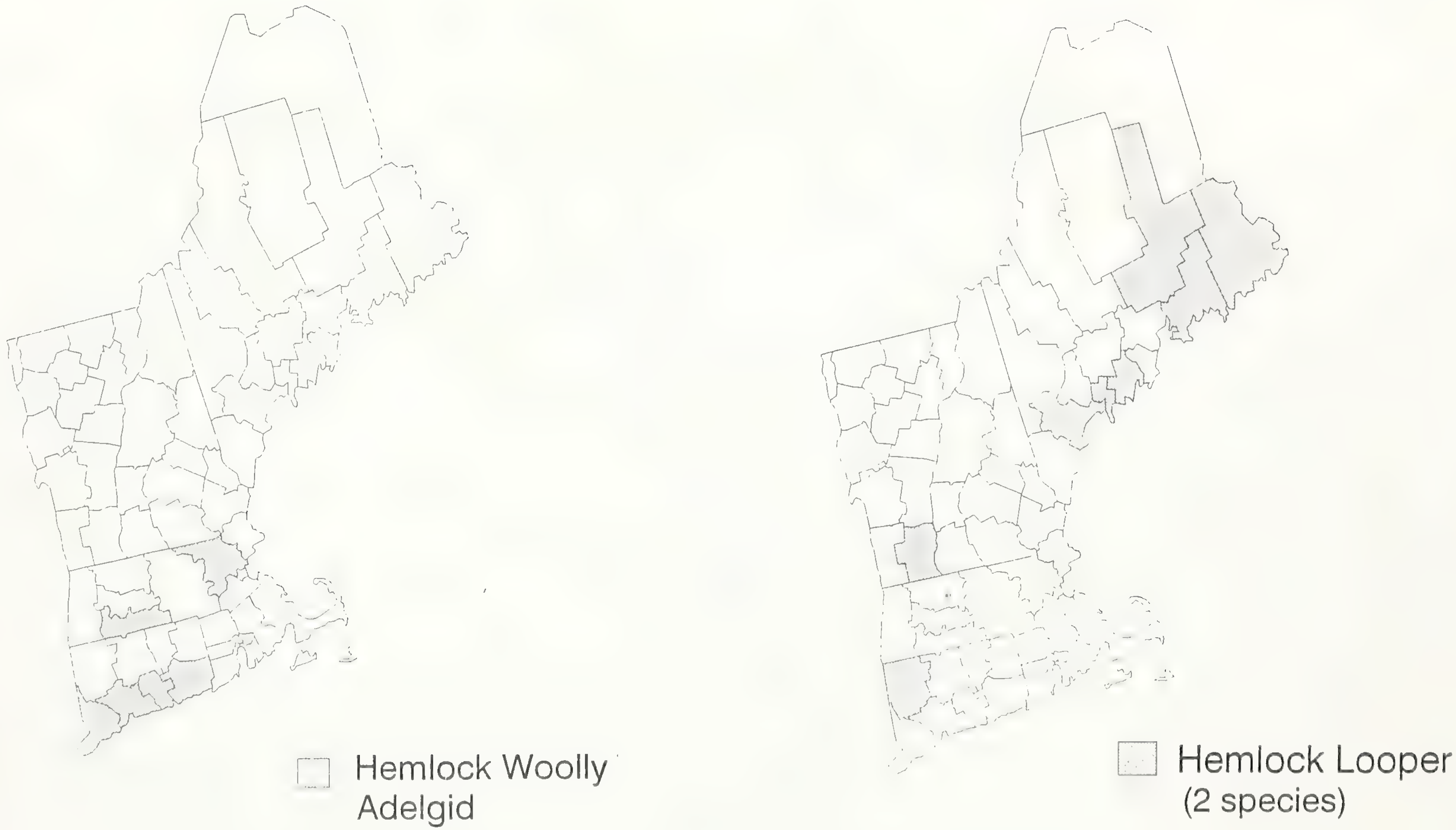

Figure 9.--Continued

Conifer insect pests. The major insect pests of conifers include defoliators, stem and twig insects, and bark beetles. Populations of the eastern spruce budworm (*Choristoneura fumiferana* [Clemens]) continue at low levels in spruce-fir forests in northern New England. There was no visible defoliation in Vermont or New Hampshire. In Maine, for the first time since 1946, no areas of moderate or severe defoliation were detected aerially. The minimal damage that was observed was confined to the southeast coastal area of the state, where populations are expected to remain at low levels. By contrast, a hemlock looper (*Lambdina* spp.) infestation in Maine is expanding at an unprecedented rate (Fig. 9). Hemlock and balsam fir are being affected and mortality is significant in some areas. The looper also caused localized defoliation in Vermont and was thought to be damaging hemlock in northern Connecticut.

Damage from the hemlock woolly adelgid (*Adelges tsugae* Annand) and red pine adelgid (*Pineus boerneri* Annand) intensified in Connecticut and Rhode Island (Fig. 9). These insects are expanding into Massachusetts. The hemlock wooly adelgid is affecting both ornamental hemlock trees and trees in forest stands, with the heaviest concentrations in the river valleys. The red pine adelgid often is found in red pine stands that are attacked by the red pine scale (*Matsucoccus resinosae* Bean & Godwin), mortality had occurred throughout affected areas in southern New England. The balsam wooly adelgid (*Adelges piceae* [Ratzeburg]) is damaging balsam fir crowns at scattered sites in northern New England. The spruce beetle (*Dendroctonus rufipennis* [Kirby]) is killing large red and white spruce, and occasionally black spruce, in northern Maine. More than half of the spruce have been killed in some stands. The area of infestation is increasing in size and intensity, particularly in areas attacked previously by the spruce budworm. The spruce beetle also is causing spruce mortality in northern New Hampshire.

Hardwood and conifer pathogens. One of the more significant diseases in the region is beech bark disease, affecting American beech within the northern hardwood forest type. Damage from this disease is found throughout the region but the amount of foliar chlorosis, tree crown dieback, and mortality varies. There are pockets of heavy mortality in all of the New England states (Fig. 10). The frequency of occurrence of scale populations, associated with the disease complex, is increasing.

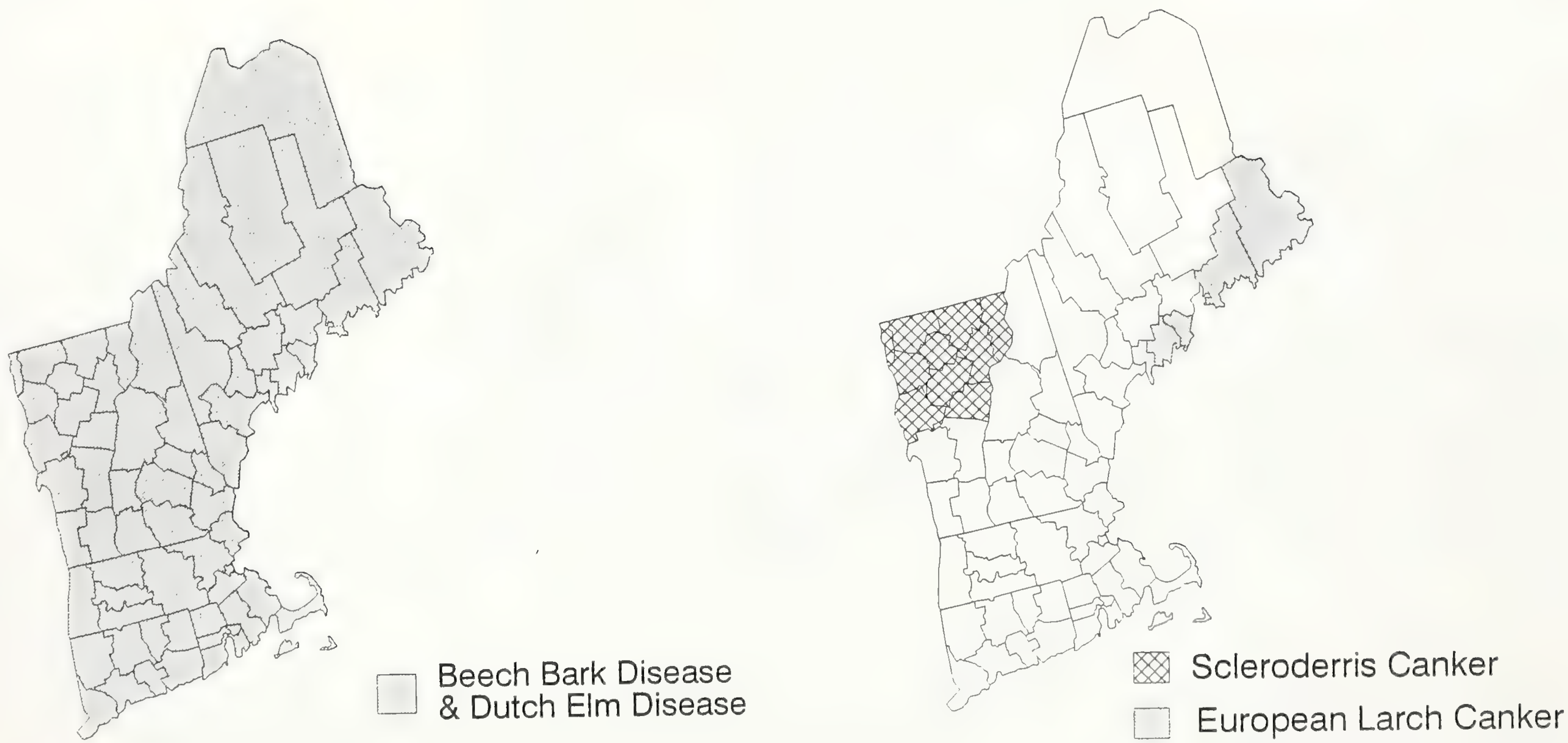

Figure 10.--Occurrence of various forest pathogens by county and state, New England, 1990

Cytospora canker (*Leucostoma kunzei* [Fr.:Fr.] Munk) on red spruce and diplodia tip blight (*Sphaeropsis sapinea* [Fr.:Fr.] Dyko & Sutton) on red pine has caused damage in several localized areas. European larch canker (*Lachnellula willkommii* [R. Hartiq] Dennis) is found on larch and tamarack along the Maine coast (Fig. 10). Heavy infection is occurring at two sites within the federal quarantine area. Scleroderris canker (*Ascocalyx abietina* [Lagerberg] Schlapfer) is still under state quarantine in northern Vermont, though the disease is currently static (Fig. 10). Scattered infections were found in a previously infected area in northwestern Maine. White pine blister rust (*Cronartium ribicola* Fisch.) is commonly found on white pine where the alternate hosts, *Ribes* spp., are present. In Maine a disease known as Still-well's syndrome, which is associated with Armillaria root disease, continues to cause low levels of mortality in balsam fir stands over an extensive area once defoliated by the spruce budworm.

Dutch elm disease (*Ophiostoma ulmi* [Buism.] Nannf.) is common throughout the region on American elm in forest stands and also on ornamental trees (Fig. 10). The severity of infection and mortality is dependent upon the agressiveness of the strain of the fungus, the population of elm bark beetles, and tree resistance. A more aggressive strain of the disease can now be found throughout the region, and trees that survived the initial wave of the disease are now becoming infected and dying.

Several foliar diseases were reported in 1990. The most significant was anthracnose (*Gloesporium* spp.), which caused browning and defoliation in the northern hardwood and oak-hickory forest types in Vermont, Massachusetts, and Rhode Island. Dogwood, sycamore, maple, oak, and other hardwoods were affected at various locations. Many tree crowns refoliated, but had tufted foliage and shoot mortality.

<u>Other diebacks and declines</u>. Several diebacks on various species were reported. Ash dieback, commonly associated with ash yellows and caused by a mycoplasma-like organism, is occurring in Maine, Vermont, and Massachusetts. White ash is the most affected species, but other ash species are susceptible. Affected trees have stunted growth along with tufted foliage and witches'-broom, and dieback has increased in severity recently. Other agents that may be causing or intensifying symptoms include drought, freezing, and viral or fungal pathogens. Larch mortality, usually in association with the eastern larch beetle (*Dendroctonus simple* LeConte) or larch casebearer (*Coleophora laricella* [Hubner]), is occurring in Vermont and Maine. Birch dieback is reported in Vermont and especially Maine, where several areas in the western and eastern parts of the state are affected. In some areas, dieback occurred in nearly all of the birch trees surveyed. Damage from the birch leaf miner (*Fenusa pusilla* [Lepeletier]) has caused additional stress in affected trees.

Dieback of sugar maple is reported throughout the region, but in most cases less that 10 percent of the crown is affected and losses are insignificant. Trees in forest stands and sugarbushes are affected, as are shade trees. Maple stands in Vermont appeared healthier than in recent years, possible due to an increase in rainfall and reduced damage from defoliators. In localized areas, damage occurred where stress factors such as overtapping, logging, and the pear thrips occurred. Dieback of red spruce continues to be reported; in some instances it is associated with known damage agents. The dieback is most noticable at the higher elevations.

Abiotic damage agents. Damage from abiotic stressors was reported to be affecting various species in localized areas. These agents include mechanical damage, drought, winter injury, frost, and storm damage.

Atmospheric Deposition and Pollution

Wet and dry deposition and ozone pollution are reported for 1989, the most recent year for which data are available.

Wet deposition in New England. There are 10 wet-deposition monitoring sites in the New England states; all are part of the National Atmospheric Deposition Program (NADP) network (Brooks et al., 1992). The highest sulfate wet-deposition rates varied seasonally between sites but often were recorded at the central Massachusetts sites, at Bennington, Vermont, or at Hubbard Brook, New Hampshire (Table 4). The same was true for nitrate and hydrogen ion wet deposition. These results follow the pattern of the previous 11 years (Brooks et al., 1992).

Dry deposition in New England. There are three dry-deposition monitoring sites in New England (Brooks et al., 1992). For the two National Dry Deposition Network (NDDN) sites (Hubbard Brook and Ashland/Caribou, Maine), Edgerton et al. (1990) reported annual averages for gas (HNO_3 and SO_2) and particulate (sulfate, nitrate, and ammonium) species. The values were, in micrograms/m^3:

Item	Hubbard Brook	Ashland
Sulfate	3.1	2.7
Nitrate	0.27	0.28
Ammonium	0.88	0.69
HNO_3	0.93	0.71
SO_2	2.8	2.4

For each deposition species listed, these annual averages were among the four lowest of all 41 NDDN sites east of the Mississippi River. The third New England site is located at Howland Forest, Maine and is part of the National Oceanic and Atmospheric Administration network. No data were available from this site for this report.

While NDDN has not yet finalized the methodology for computing deposition amounts, Edgerton et al. (1990) did obtain a range of annual dry-deposition estimates by making certain (gross) assumptions about various parameters which enter the dry deposition calculations. When these ranges for dry deposition are combined with the 1989 annual wet-deposition totals from nearby sites, one finds that total deposition of both sulfate and nitrate probably was composed primarily of wet deposition at the two sites. At Hubbard Brook in 1989, precipitation seemed to account for 78 to 87 percent of total sulfate deposition, and for 75 to 86 percent of total nitrate deposition, for the Ashland/Caribou area in Maine, wet deposition seemed to account for 60 to 75 percent of total sulfate and between 64 to 78 percent of total nitrate.

Table 4. Quarterly[1] sulfate, nitrate, and hydrogen ion wet deposition totals at ten monitoring sites[2], New England, 1989.

Sites	Sulfate				Nitrate				Hydrogen			
	1	2	3	4	1	2	3	4	1	2	3	4
	(kg/ha)											
Caribou, ME	nd[3]	3.17	3.11	nd	nd	1.86	1.72	nd	nd	0.06	0.06	nd
Bridgton, ME	2.51	6.97	nd	nd	1.89	3.9	nd	nd	0.05	0.14	nd	nd
Greenville, ME	1.69	4.43	4.85	1.91	2.80	3.06	2.38	2.46	0.06	0.09	0.09	0.05
Acadia NP, ME	4.22	nd	3.87	5.03	2.7	nd	2.24	3.58	0.08	nd	0.08	0.1
Hubbard Brook, NH	3.43	6.66	9.09	nd	3.21	4.56	5.17	nd	0.09	0.15	0.17	nd
Underhill, VT	3.48	4.72	6.8	3.45	4.64	3.48	4.35	4.52	0.1	0.1	0.14	0.1
Bennington, VT	3.9	6.54	9.01	3.81	3.74	5.01	4.68	4.33	0.1	0.14	0.16	0.09
Cape Cod, MA	nd	5.57	4.38	nd	nd	2.99	2.42	nd	nd	0.09	0.08	nd
Waltham, MA	5.1	8.71	7.93	5.2	2.74	3.89	4.09	3.18	0.1	0.18	0.16	0.11
Quabbin Reservior, MA	3.57	9.23	5.89	nd	2.68	6.63	3.62	nd	0.08	0.21	0.1	nd

[1]Quarters are: 1 = January, February, March; 2 = April, May, June; 3 = July, August, September; 4 = October, November, December.

[2]data supplied by NADP/NTN (1990).

[3]nd are missing values due to the failure of the data to satisfy data completeness criteria.

Ozone. A summary seasonal ozone-exposure statistic (SUM06) is available for six sites in New England designated as forested by the Atmospheric Information and Retrieval System (AIRS) (Brooks et al., 1992). This statistic is the sum of all hourly average ozone concentrations greater than or equal to 0.060 ppm for April through October. For 1989, Stafford, Connecticut, and Quabbin Reservoir, Massachusetts show the highest seasonal SUM06 values for the six sites (Table 5). The other sites show relatively low SUM06 values, 20 ppm-hr or less. Within the time-series of seasonal SUM06 values for New England, 1989 ozone levels were moderate (Brooks et al., 1992).

Ozone-exposure values for New England in 1989 were substantially less than comparative values for San Bernardino, California (1981-85 minimum value 154 ppm-hr; Bohm and Vandetta 1990). Lefohn and Lucier (1991) decribe northern New England/New York ozone exposure as relatively low compared to other regions of the United States.

Table 5.--Valid hourly average ozone readings (of a possible 5,136 hours) and uncorrected (UNCORR) and corrected (CORR) seasonal SUM06 values[1] for six New England ozone monitoring sites, 1989

SITE	Valid hourly readings	SUM06	
		UNCORR	COOR
	No. hours	--ppm-hr--	
Stafford, CT	4,434	38.599	44.460
Acadia NP, ME	4,584	17.724	20.149
Mt. Greylock, MA	3,923	15.821	19.497
Quabbin Reservoir, MA	5,064	53.741	54.486
Hubbard Brook, NH	4,884	13.589	13.952
Chittenden County, VT	4,082	17,651	19,411

[1]SUM06 is the sum of all hourly average ozone concentrations greater than or equal to 0.060 ppm for April through October; the uncorrected index is the sum of nonmissing ozone hourly data; the corrected index standardizes for missing data.

Climate and Weather

Climate and weather information are presented for October 1989 to September 1990. Weatherconditions over this 12-month period influenced the tree conditions surveyed in the summer of 1990. Weather during the last quarter of 1990 would have no influence on 1990 field-season tree conditions. Weather and climate information are presented as isopleth maps constructed using a geographic information system (GIS) and National Weather Service data.

Figure 11 shows that mean annual 1990 New England temperatures follow the typical south to north gradient evident in the long-term area record (Brooks et al., 1992). Slightly cooler than normal conditions prevailed in southern Vermont and southeastern Maine (Fig. 12), with slightly warmer than normal conditions elsewhere. Annual estreme maximum temperatures were near or slightly cooler than the 30-year normal (Figs. 13-14) while annual minimum extreme temperatures were below normal for much of Maine and near to slightly above normal for the remainder of New England (Figs. 15-16).

An irregular pattern of precipitation was reported across New England during 1990 (Fig. 17). With the exception of north-central and southern coastal Maine, the region reported near normal or wet conditions. Some areas reported 10 to 15 inches of rain in excess of 30-year average annual totals (Fig. 18).

Values of mean growing season Palmer Drought Severity Index (PDSI) values reflect the temperature and precipitation patterns described. Near normal to slightly wet conditions (i.e., PDSI between 0.0 and 1.0) prevailed in Maine in 1990 (Fig. 19). Excessive precipitation overrode the increased moisture demands of above average temperatures to generate slightly wet to very wet (i.e., large positive) PDSI values for the rest of New England. The largest positive PDSI values were found in northeastern Vermont, western Massachusetts, and central Connecticut.

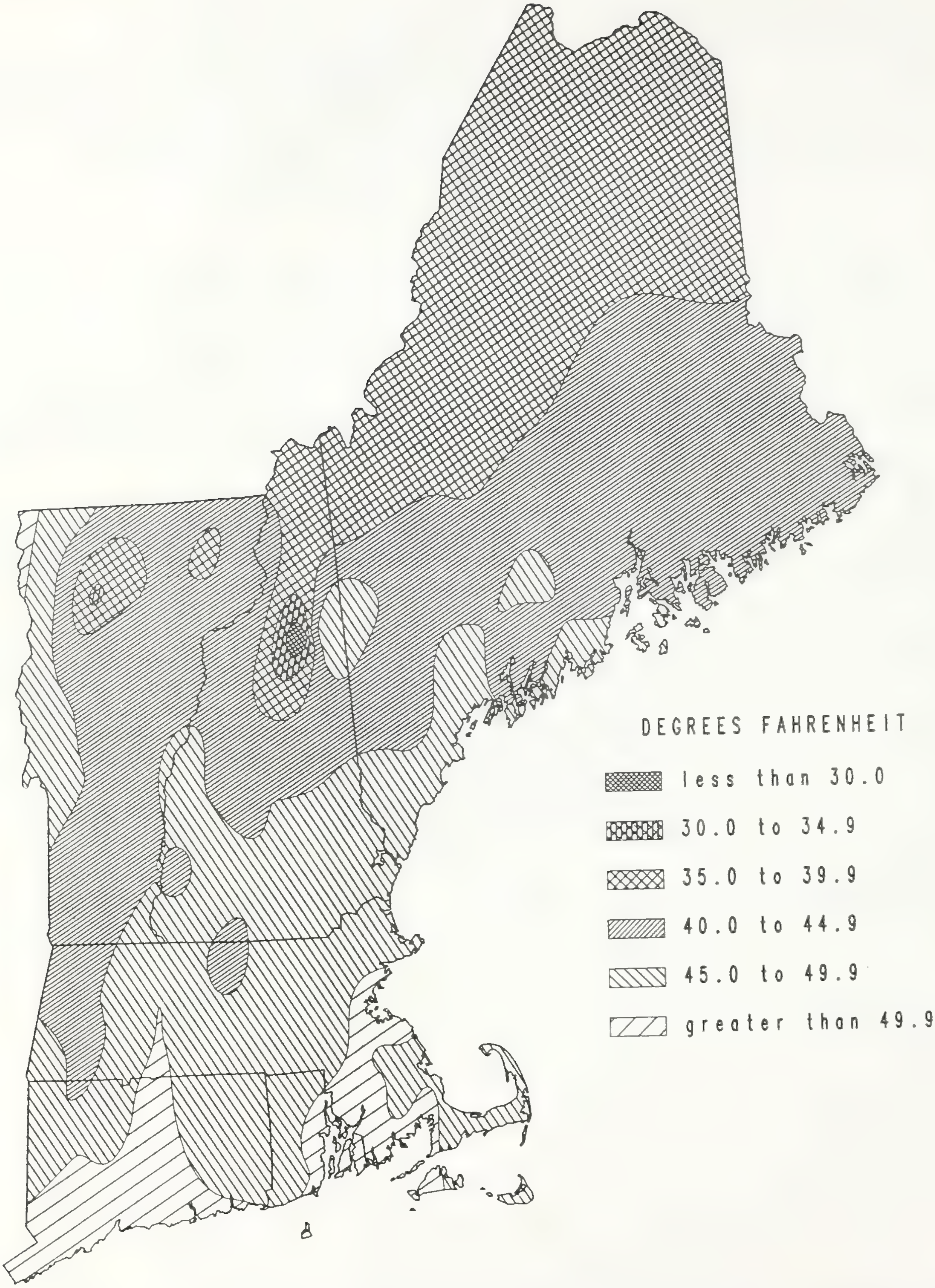

Figure 11.--Isopleth map of mean annual temperature in New England, October 1989 through September 1990.

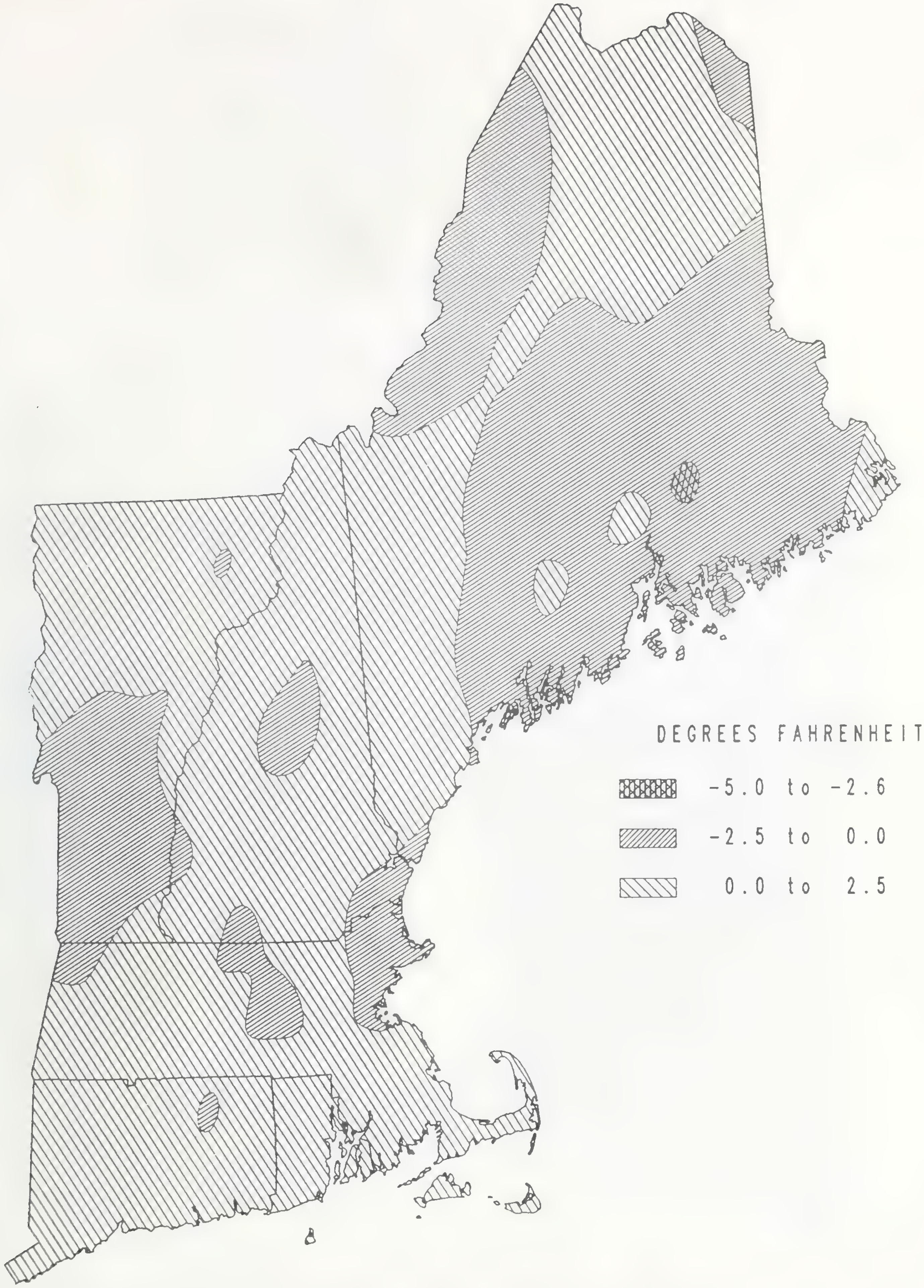

Figure 12.--Isopleth map of mean annual temperature deviations from the 30-year average, New England, October 1989 through September 1990.

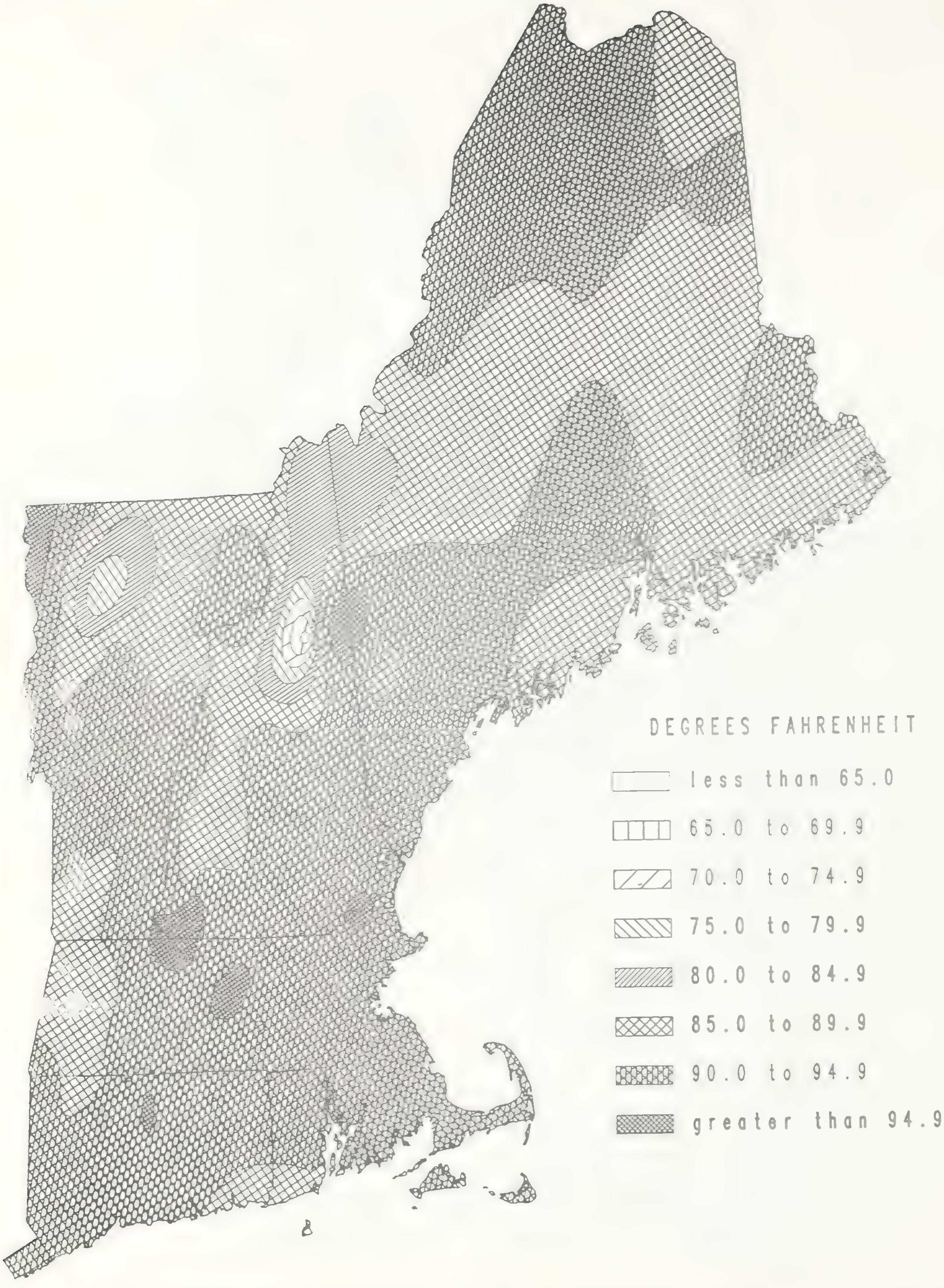

Figure 13.--Isopleth map of annual maximum temperature in New England, October 1989 through September 1990.

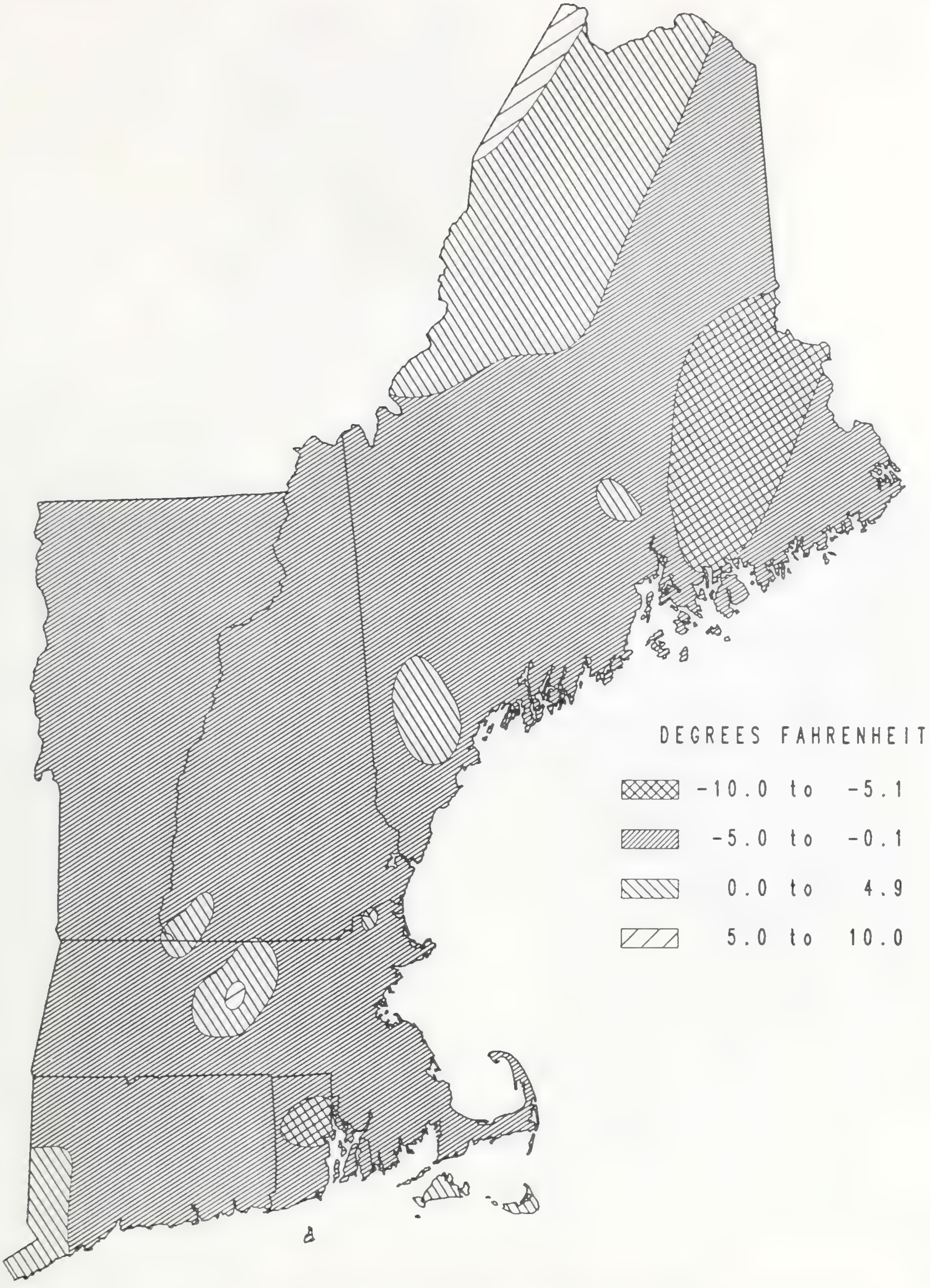

Figure 14.--Isopleth map of annual maximum temperature deviations from the 30-year average, New England, October 1989 through September 1990.

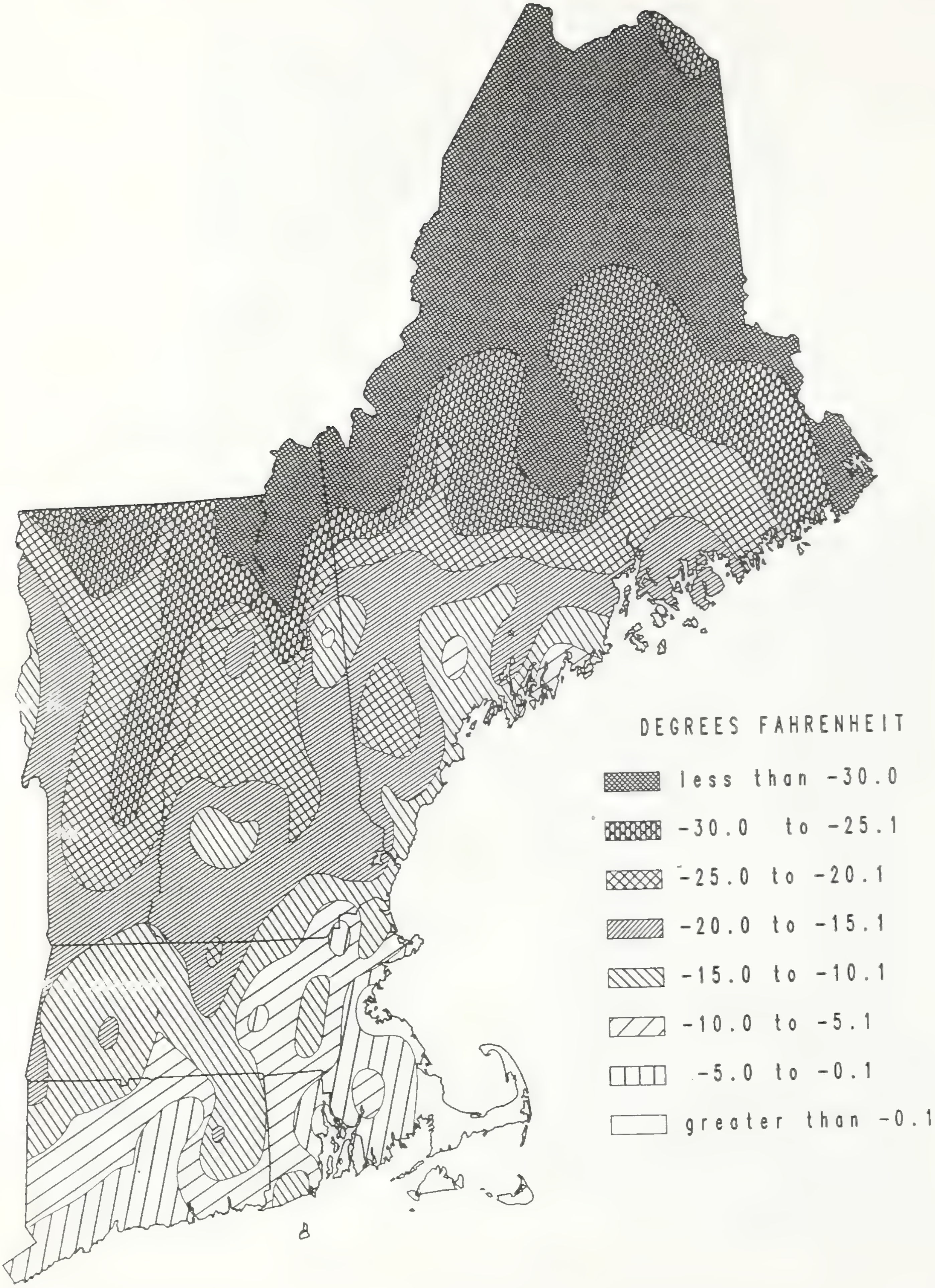

Figure 15.--Isopleth map of annual minimum temperature in New England, October 1989 through September 1990.

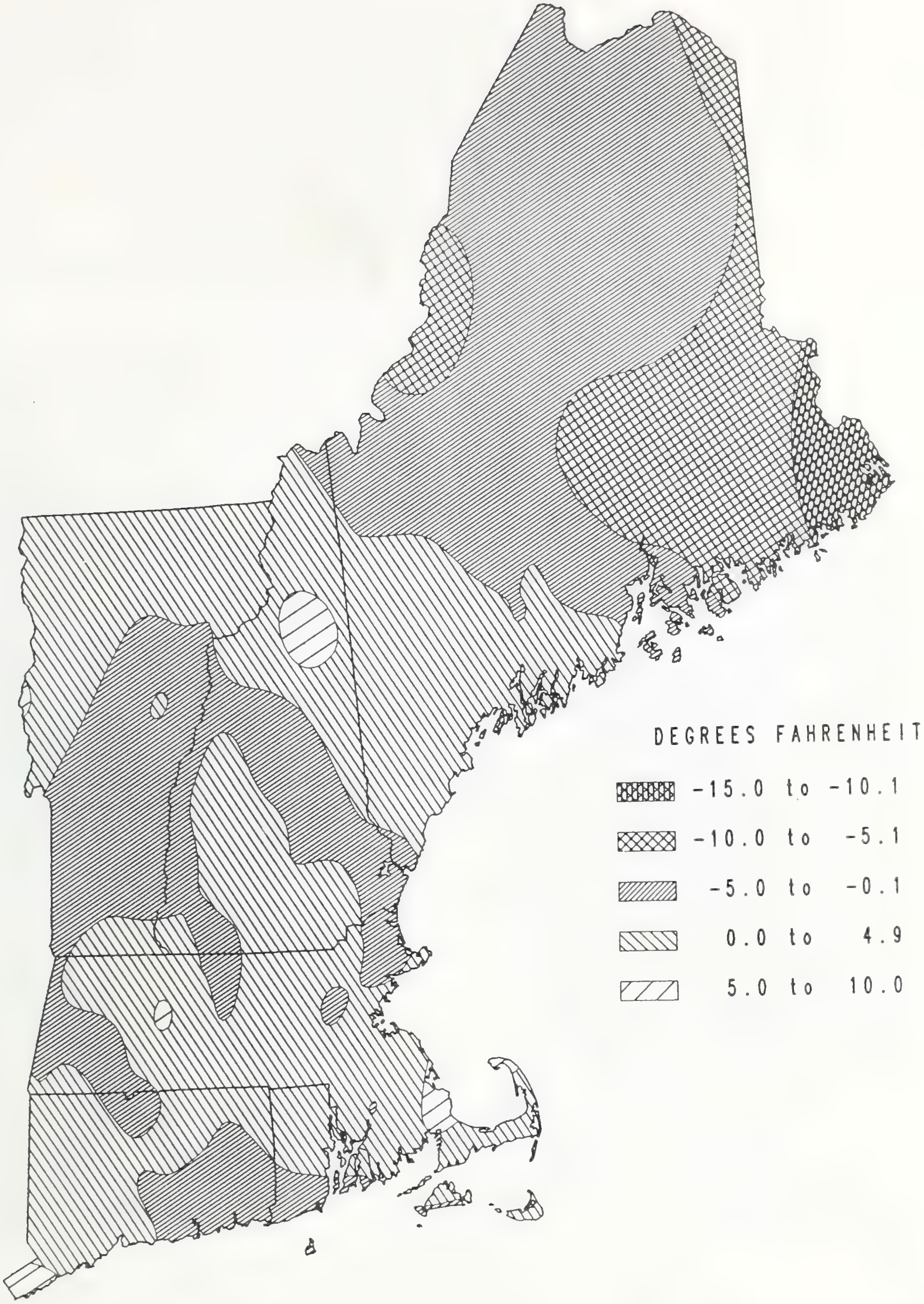

Figure 16.--Isopleth map of annual minimum temperature deviations from the 30-year average, New England, October 1989 through September 1990.

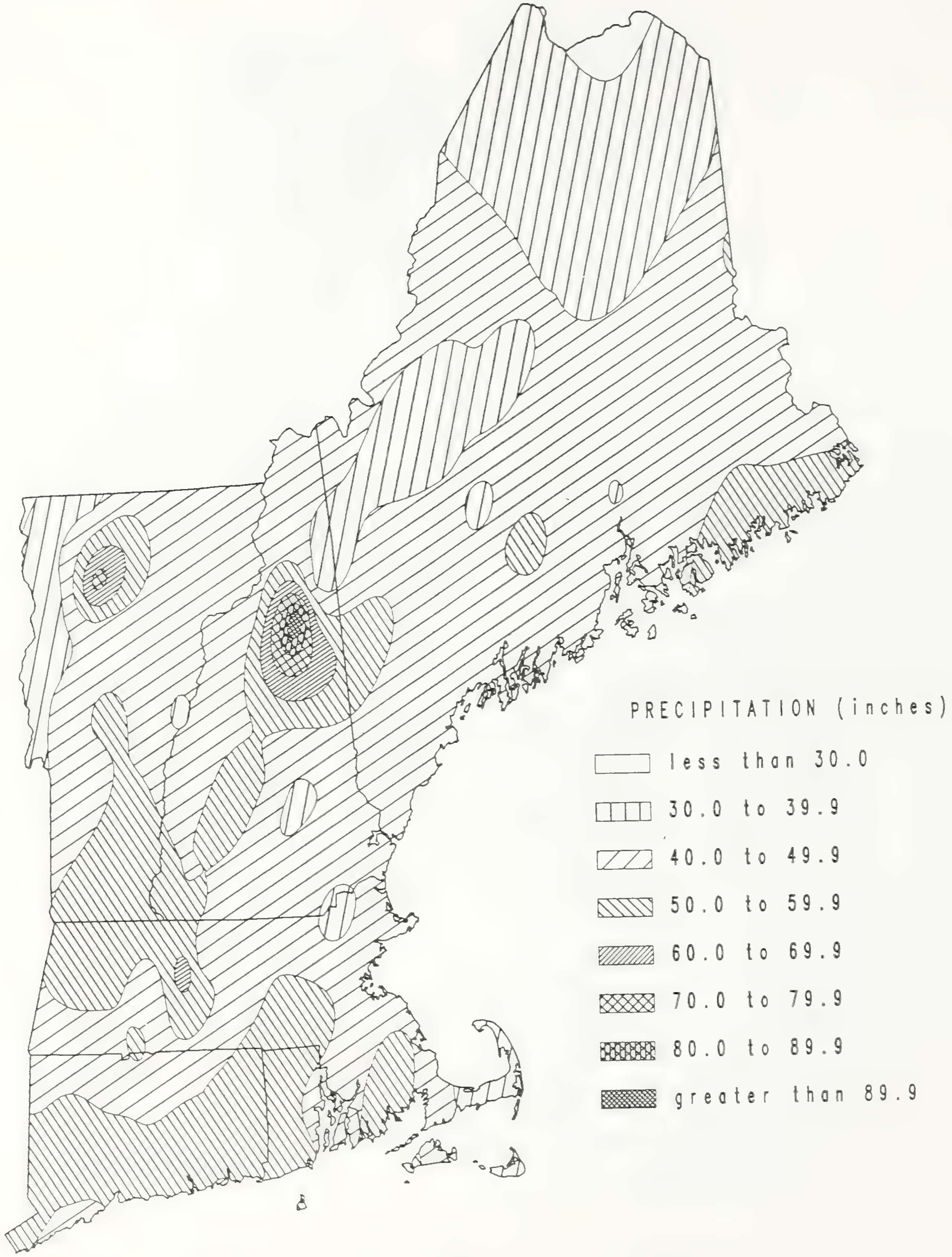

Figure 17.--Isopleth map of annual precipitation in New England, October 1989 through September 1990.

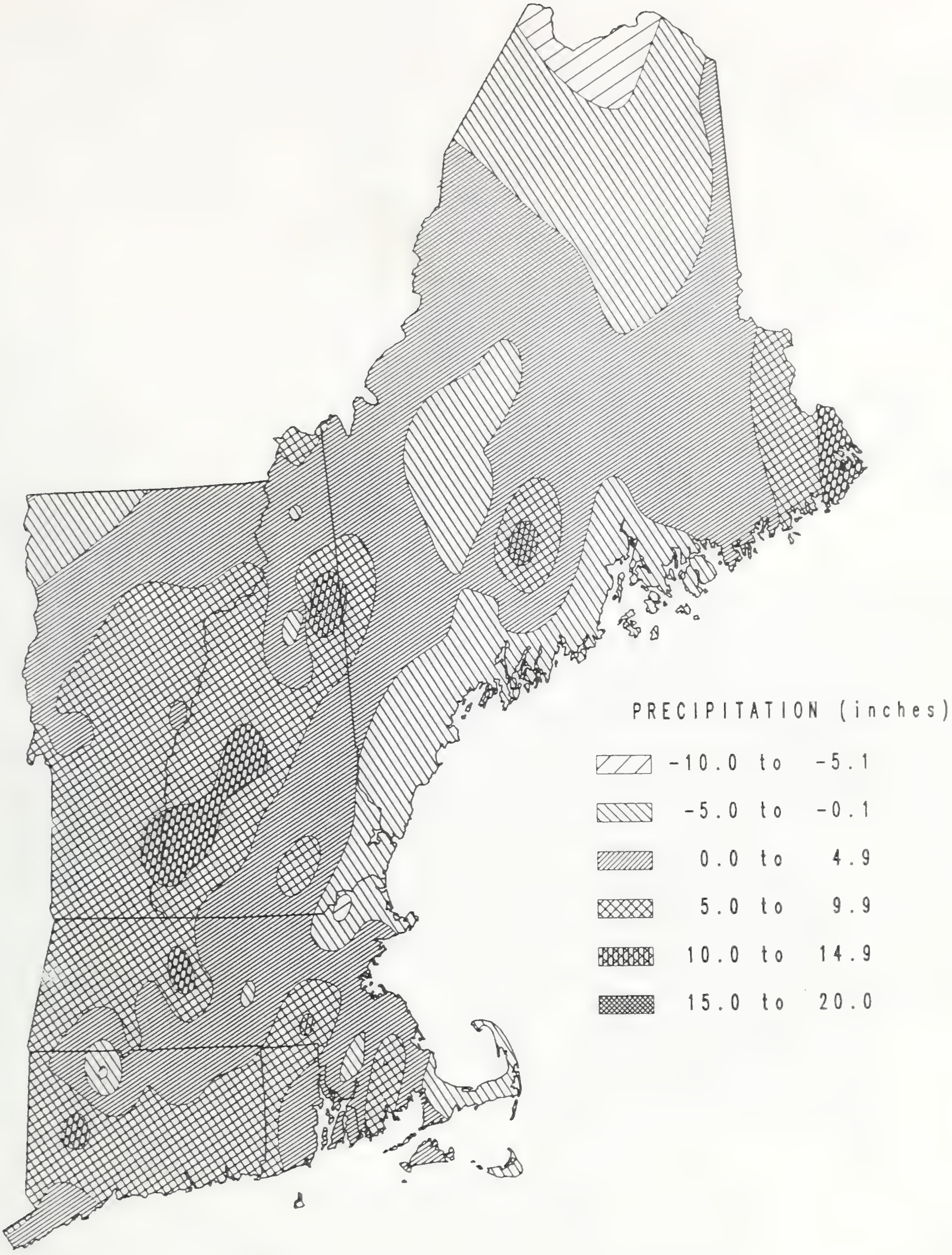

Figure 18.--Isopleth map of annual precipitation deviations from the 30-year average, New England, October 1989 through September 1990.

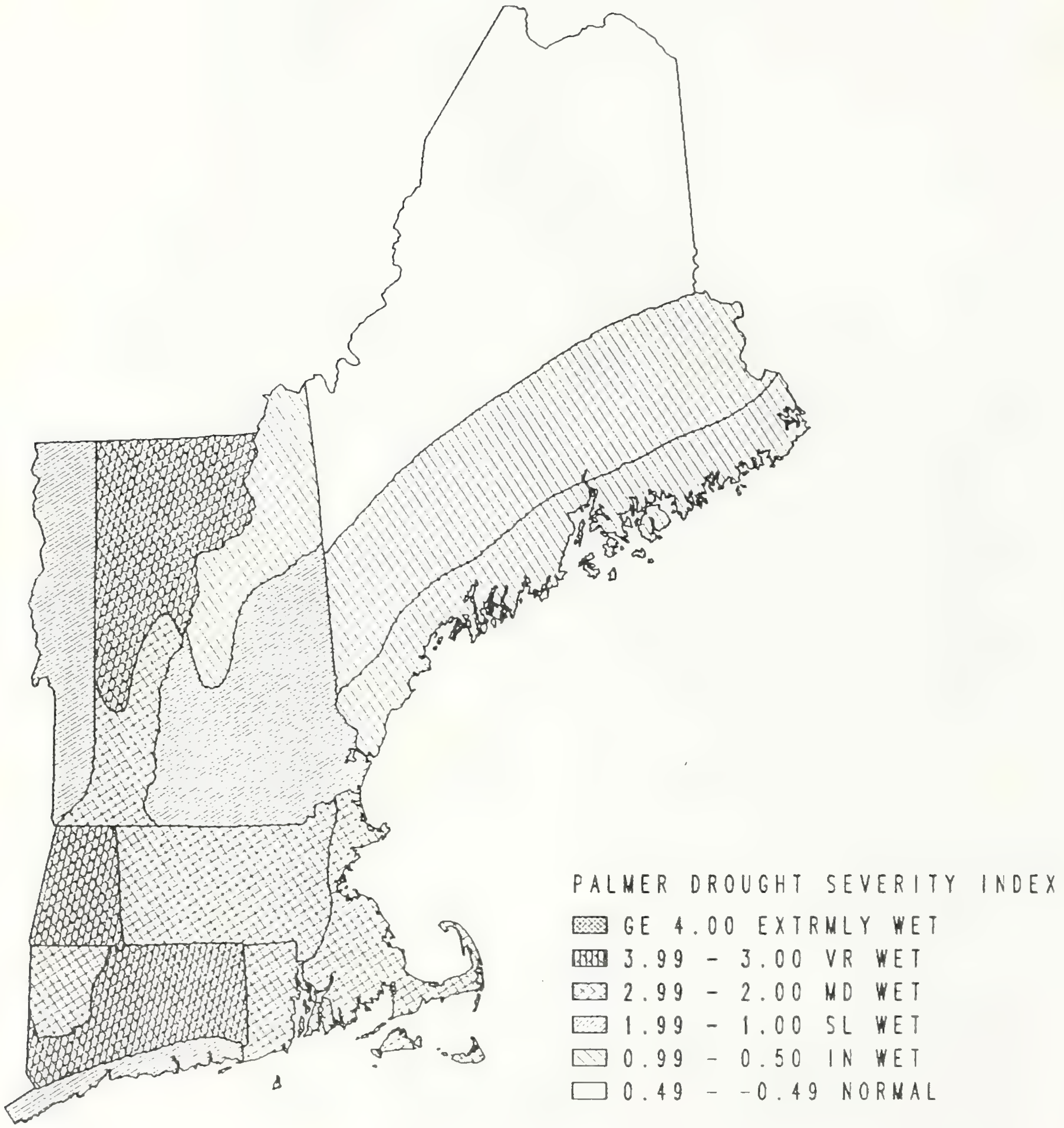

Figure 19.--Mean growing-season Palmer Drought Severity Index, New England, 1990 (range: -4.00=extremely dry; +4.00=extremely wet).

Summary

The objectives of the 1990 FHM field season to establish a permanent plot network and to collect first-year crown rating and growth data. The full value of these data and of diameter measurements will be realized with plot remeasurements in succeeding years.

The FHM plot sample corresponds closely to characteristics of New England's forest resource as reported by FIA. The distribution of plots by forest/nonforest, forest-type group, and stand-size class are not significantly different from expectations. Likewise, the distribution of trees on the FHM plots by species is not significantly different from our expectations, and the deviations that were found fcan be explained on the basis of known changes in New England forests since the last extensive survey.

Crown-rating data from upper canopy trees on FHM plots indicate no pattern of major decline in any species. Generally, where results indicate a health issue (e.g., for American beech), known natural agents are the probable cause. For many species, these data represent the first such measurement, so an exact interpretation is difficult.

Acknowledgements

Forest Health Monitoring in New England is a continuing, cooperative effort by the USDA Forest Service, U.S. Environmental Protection Agency (EPA), and the National Association of State Foresters (NASF). Within the Forest Service, Research has overall responsibility for the FHM activities reported in this publication, and is assisted by the Forest Health Protection group of State and Private Forestry. The EPA's Environmental Monitoring and Assessment Program (EMAP-Forests) assists in the design of the sampling system, training, and quality-assurance activities, data handling and management, and reearch on additional indicators of forest health and condition. FHM data are used by the EPA in its EMAP assessments. The NASF supports FHM through its participation on the program's oversight and technical committees. The staffs of the State Foresters of the six New England states helped develop the FHM program by collecting field data and providing technical assistance. The Northeastern Forest Experiment Station's Forest Inventory and Analysis group assisted in the design of the plot systems, training of field crews, and data management and processing. The Durham, New Hampshire, Field Office of the Northeastern Area, State and Private Forestry assisted in assessing crown condition and training field crews, and provided portable field-data recorders.

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Appendix

Definition of Terms

Bog/marsh/swamp. Land that has less than 10.0 percent stocking with live trees; and which characteristically supports low, generally herbaceous or shrubby vegetation, and which is intermittently covered with water during all seasons; includes tidal areas that are covered with salty or brackish water during high tides.

Cropland. Land that currently supports agricultural crops including silage and feed grains, bare farm fields resulting from cultivation or harvest, and maintained orchards.

Crown class. A classification of individual tree crowns used to describe tree vigor in relation to sunlight the crown receives and the tree's position in relation to neighboring trees. Five crown classes are recognized:

a. Open grown--trees with crowns which receive full sunlight from above and all sides throughout most of the life of the tree; their crowns have not been and are not likely to be influenced by neighboring trees.

b. Dominant--trees with crowns extending above the general level of the forest canopy and receiving full sunlight from above and partly from the sides, larger than average trees in the stand, with crowns well developed but possibly crowded on the sides by neighboring trees.

c. Codominant--trees with crowns forming the general forest canopy and receiving full sunlight from above but comparatively little from the sides, usually with medium-size crowns, more or less crowded on the sides by neighboring trees.

d. Intermediate--trees with crowns below or barely extending into the general forest canopy and receiving little direct sunlight from above and none from the sides, usually with small crowns and considerably crowded on the sides by neighboring trees.

e. Suppressed--trees with crowns entirely below the general forest canopy and receiving no direct sunlight from above or from the sides.

Crown dieback. A tree-crown characteristic defined as tree branch mortality that begins at the terminal portion of the branch and proceeds toward the main stem of the tree. Whole branches that are dead in the upper, exposed portion of the crown are classed as dieback; whole dead branches within the lower portion of the crown are assumed to have died of suppression.

Damage signs or symptoms. A whole-tree characteristic that records external signs or symptoms of serious damage a tree has experienced that are expected to result in its decline or death.

Developed recreation site. Parks, campgrounds, playing fields, athletic and sports tracks, etc.

Diameter at breast height (d.b.h). The diameter outside bark of a standing tree measured at 4-1/2 feet above the ground.

Foliage discoloration. A tree crown characteristic that rates the premature appearance of the crown as noticeably yellow, red, or brown.

Foliage transparency. A tree-crown characteristic intended as an estimate of foliage density for the crown as a whole. Transparency includes normal species characteristics of foliage density as well as reductions of foliage caused by insect damage, pathogens, or environmental stress. Measured as the amount of skylight visible through the foliated portion of the tree crown.

Forest land. Land at least 10 percent stocked by trees of any size or formerly having had such tree cover and not currently developed for agricultural use. The land must be a minimum of 1 acre in area or at least 120 wide if linear in shape.

Forest type. A classification of forest land based on the species that form a plurality of live tree basal area stocking.

Forest-type group. A combination of forest types that share closely associated species or site requirements. The many forest types in New England were combined into the following major forest-type groups (the descriptions apply to forests in New England):

a. White pine--forests in which white pine, hemlock, or red pine make up the plurality of the stocking, singly or in combination; common associates include red spruce, maple, and yellow-poplar.

b. Spruce-fir--forests in which red spruce, northern white-cedar, balsam fir, white spruce, black spruce, or tamarack, singly or in combination, make up a plurality of the stocking; common associates include yellow birch and red maple.

c. Oak-pine--forests in which northern red oak or white ash, singly or in combination, make up a plurality of the stocking but where pines or eastern redcedar contribute 25 to 50 percent of the stocking; hemlock, maple, sweet birch, and yellow-poplar are associates.

d. Oak-hickory--forests in which upland oaks, red maple (when associated with central hardwoods), or hawthorn, singly or in combination, make up a plurality of the stocking and in which white pine makes up less than 25 percent of the stocking; common associates include hard pines, hemlock, maple, birch, hickory, and yellow-poplar.

e. Elm-ash-red-maple--forests in which black ash, elm, red maple (when growing on wet sites), willow, or green ash, singly or in combination, make up a plurality of the stocking; common associates include sugar maple, hickory, yellow-poplar, and black cherry.

f. Northern hardwoods--forests in which sugar maple, beech, yellow birch, red maple (when associated with northern hardwoods), pin cherry, or black cherry, singly or in combination, make up a plurality of the stocking; common associates include hard pines, hemlock, hickory, ash, and yellow-poplar.

g. Aspen-birch--forests in which aspen, paper birch, or gray birch, singly or in combination, make up a plurality of the stocking.

h. Other forest-type groups--includes aspen-birch, oak-pine, and elm-ash-red maple forest types when these types are not individually identified.

Hardwoods. Dicotyledonous trees, usually broad-leaved and deciduous.

Idle farmland. Former cropland or pasture that has not been tended within the last 2 years and has less than 10.0 percent stocking with live trees (established seedlings or larger trees), regardless of species.

Improved pasture. Land that is currently used and maintained for grazing (not including grazed cropland).

Industrial, commercial land. Supply yards, parking lots, shopping centers, factories, waste disposal sites, etc.

Multiple family housing. Multiple individual residential units or attached units (e.g. apartment buildings, condominiums) and immediately adjacent managed land.

Needle retention. A crown characteristic of softwoods that rates the number of years that needles are retained by a tree; measured as the year of the oldest branch internode with more than 25 percent of needles present.

Noncensus water. Streams/rivers between 120 feet and 1/8 mile in width, and bodies of water between 1 and 40 acres in size. The Bureau of the Census classifies such water as land.

Nonforest land. Land that has never supported forests, or land formerly forested but now in nonforest use such as cropland, pasture, residential areas, or highways.

Nonstocked area. A stand-size class of forest land that is stocked with less than 10 percent of minimum full stocking with all-live trees.

Other farmland. All nonforest land on a farm excluding cropland, pasture, and idle farmland; includes farm lanes, stock pens, and farmsteads.

Other land. Any nonforest land not included in any other nonforest land classification.

Poletimber stand. A stand-size class of forest land that is stocked with at least 10 percent of minimum full stocking with all-live trees with half or more of such stocking in poletimber or sawtimber trees or both, and in which the stocking of poletimber exceeds that of sawtimber.

Poletimber trees. Live trees of commercial species meeting regional specifications of soundness and form and at least 5.0 inches in d.b.h., but smaller than sawtimber trees.

Rights-of-way. Highways, pipelines, powerlines, canals.

Sampling error. A measure of the reliability of an estimate, expressed as a percentage of the estimate. The sampling errors given in this report correspond to one standard deviation and are calculated as the square root of the variance, divided by the estimate, and multiplied by 100.

Saplings. Live trees 1.0 inch through 4.9 inches d.b.h.

Sapling-seedling stand. A stand-size class of forest land that is stocked with at least 10 percent of minimum full stocking with all-live trees with half or more of such stocking in saplings or seedlings or both.

Sawtimber stand. A stand-size class of forest land that is stocked with at least 10 percent of minimum full stocking with all-live trees with half or more of such stocking in poletimber or sawtimber trees or both, and in which the stocking of sawtimber is at least equal to that of poletimber.

Sawtimber trees. Live trees of commercial species at least 9.0 inches d.b.h. for softwoods or 11.0 inches for hardwoods, containing at least one 12-foot sawlog or two noncontiguous 8-foot sawlogs, and meeting regional specifications for freedom from defect.

Seedlings. Live trees less than 1.0-inch d.b.h. and at least 1 foot tall.

Single-family housing. House sheltering one family and immediately adjacent managed land.

Softwoods. Coniferous trees, usually evergreen and having needles or scale-like leaves.

Stand. A group of forest trees growing on forest land.

Stockings. The degree of occupancy of land by trees, measured by basal area and/or number of trees in a stand compared to the basal area and/or number of trees required to fully use the growth potential of the land (or the stocking standard). In the Eastern United States this standard is 75 square feet of basal area per acre for trees 5.0 inches d.b.h. and larger, or its equivalent in numbers of trees per acre for seedlings and saplings.

Trees. Woody plants that have well-developed stems and are usually more than 12 feet tall at maturity.

Common and Scientific Names of Tree Species on New England FHM plots.

Common name(s)	Scientific name[1]
	CONIFEROUS SPECIES
Balsam fir	*Abies balsamea*
Eastern redcedar	*Juniperus virginiana*
Larch (introduced)	*Larix* spp.
Tamarack (native)	*L. laricina*
Norway spruce	*Picea abies*
White spruce	*P. glauca*
Black spruce	*P. mariana*
Blue spruce	*P. pungens*
Red spruce	*P. rubens*
Red pine	*Pinus resinosa*
Pitch pine	*P. rigida*
Eastern white pine	*P. strobus*
Northern white-cedar	*Thuja occidentalis*
Eastern hemlock	*Tsuga canadensis*
	DECIDUOUS SPECIES
Maple species	*Acer* spp.
Striped maple	*A. pensylvanicum*
Red maple	*A. rubrum*
Silver maple	*A. saccharinum*
Sugar maple	*A. saccharum*
Mountain maple	*A. spicatum*
Tree-of-heaven, ailanthus	*Ailanthus altissima*
Serviceberry	*Amelanchier* spp.
Yellow birch	*Betula alleghaniensis*
Sweet birch	*B. lenta*
River birch	*B. nigra*
Paper birch	*B. papyrifera*
Gray birch	*B. populifolia*
American hornbeam, musclewood	*Carpinus caroliniana*
Hickory species	*Carya* spp
Bitternut hickory	*C. cordiformis*
Pignut hickory	*C. glabra*
Shagbark hickory	*C. ovata*
American chestnut	*Castanea dentata*
Flowering dogwood	*Cornus florida*
American beech	*Fagus grandifolia*
White ash	*Fraxinus americana*
Black ash	*F. nigra*
Green ash	*F. pennsylvanica*

Common name(s)	Scientific name[1]
Butternut	*Juglans cinerea*
Black walnut	*J. nigra*
Tulip-poplar, yellow-poplar	*Liriodendron tulipifera*
Apple species	*Malus* spp.
Blackgum	*Nyssa sylvatica*
Eastern hophornbeam, ironwood	*Ostrya virginiana*
Balsam poplar	*Populus balsamifera*
Eastern cottonwood	*P. deltoides*
Bigtooth aspen	*P. grandidentata*
Quaking aspen	*P. tremuloides*
Cherry, plum	*Prunus* spp.
Pin cherry	*P. pensylvanica*
Black cherry	*P. serotina*
Chokecherry	*P. virginiana*
White oak	*Quercus alba*
Swamp white oak	*Q. bicolor*
Scarlet oak	*Q. coccinea*
Blackjack oak	*Q. marilandica*
Pin oak	*Q. palustris*
Chestnut oak	*Q. prinus*
Northern red oak	*Q. rubra*
Black oak	*Q. velutina*
Willow species	*Salix* spp.
Black willow	*S. nigra*
Sassafras	*Sassafras albidum*
American mountain-ash	*Sorbus americana*
Basswood species	*Tilia* spp.
American basswood	*T. americana*
Elm species	*Ulmus* spp.
American elm	*U. americana*
Slippery elm	*U. rubra*

[1]according to Little (1979).

Estimation of Sampling Errors

With Forest Health Monitoring, the populations of interest are the forest type groups. Rather than setting desired sample sizes by population, a systematic sampling design has been used across populations. Thus, population sample sizes are not set or known prior to observation. The following method was used to develop the tables and their sampling errors.

For the New England FHM, the tables represent sums of the total number of trees/occurrence of each type of observation across all plots in the population. These table values (totals) can be written as:

$$T_{ij} = n\,\bar{y}_{ij} \qquad (1)$$

where:

T_{ij} = total of attribute j in type group i
n = total number of plots in population
$\bar{y}_{ij}$ = average of attribute j in type group i

$$= \sum_{k=1}^{n} y_{ijk}/n$$

y_{ijk} = value of attribute j in type group i on plot k

The variance of T_{ij} is computed over all plots in sample. Thus plots in other type groups are represented as zero. The variance is estimated as:

$$v(T_{ij}) = n^2\, v(\bar{y}_{ij}) = n \sum_{k=1}^{n} (y_{ijk} - \bar{y}_{ij})^2/(n-1) \qquad (2)$$

where:

$v(\bar{y}_{ij})$ = variance of the mean over all populations

Quality Assurance Report

Introduction

Quality Assurance (QA) was an integral portion of the 1990 FHM project. The objectives of the QA portion of this project were to:

1. Assist in the development of clear, concise methodology for collecting project data.

2. Develop measurement quality objectives (MQO's) that identify data-quality limits for all variables and collected data.

3. Assist in the development and evaluation of the training session for field crews.

4. Audit the field crews' collecting data to ensure compliance with project methodology.

5. Coordinate and evaluate data from a remeasurement of a proportion of the field plots to quantify data quality.

The QA information that is obtained will assist in interpreting and evaluating project results, and be used to develop realistic MQO's, revise methodology to reduce errors, and improve the quality of project data from year to year. Prior to the 1991 field season, the QA data were used to improve the methods manual, modify the training session, and update the MQO's.

Methods Manual

A methods manual describing all necessary procedures was developed prior to the 1990 field season. Many of the procedures were based on previously developed methodology from Forest Response Program (FRP) projects. The methods describe all of the required equipment, calibration and/or maintenance procedures, steps for collecting data, reporting units and/or codes, and MQO's. The methods were revised prior to the 1991 field season on the basis of editorial reviews of the manual, evaluation by field crews, and experiences from the 1990 field season.

Measurement Quality Objectives

MQO's are specific goals that define data quality from the measurement process. Specific measures of data quality are accuracy, precision, and completeness. These values are based on previous FRP project performance. The remeasurement of a subset of sample locations allows an evaluation of 1990 MQO's for revision for the 1991 field season.

The amount of usable data also depended on the proper selection of data codes. Many of the QA concerns about data management were related to an internal check program for the data recorder. Included are checks for invalid or nonexistent codes, unusual or out-of-range codes, and relational codes. The checks did not eliminate measurement errors or the selection of incorrect codes. Also, a plot could not be "closed out" in the data recorder if it contained empty fields.

Training

A training session was conducted for all crew personnel and project coordinators to introduce methodology to the field crews and evaluate their performance. The session incorporated most aspects of data collection assigned to field crews and included most of the variables that were measured. Each indicator group of measurements was a subset of the entire training session. Experts in each of the indicator measurements led the training in their subset group.

The evaluation of the training session covered three major areas. First, each individual subset training group had some level of testing under simulated field conditions; crew members were tested individually to determine their familiarity with the procedures. This information was used immediately to evaluate the effectiveness of the crown rating and identified individuals who required additional training.

Second, field crews were evaluated on a simulated FHM plot. Individual crew members were paired into their respective teams, so the evaluation was based on crew rather than individual performance. The simulation included everything that is expected of a field crew during actual data collection.

Third, the training session was evaluated by field crews; 33 individuals completed a questionnaire concerning the training session, instructors, organization, and evaluation procedures. This information was used to improve the effectiveness of subsequent sessions. Of the negative comments received, the majority indicated that the training session was too long, the amount of field work was insufficient (less class work), the level of detail was inappropriate for some individuals, and/or that the organization of training should be improved.

Audits

Audits or field visits with crews are important in evaluating the implementation of methodology. The visits also provide feedback from field crews about the project. All but two field crews received an audit visit. Other technical visits were conducted by members of the technical committee and state coordinators. This information will be used to evaluate the effectiveness of the training session, identify logistical problems, and address problems encountered in interpreting the methodology.

All field crews were asked to complete a debriefing questionnaire following the 1990 field season. Comments identified problems related to the training session in addition to those identified earlier, methods manual, coding, the implemention of certain variables under field conditions, data entry (tally sheets and portable data recorders), and the quality of photos for plot location.

Remeasurement of Plots

Every crew had at least one of its sample locations remeasured so that comparability could be quantified. The remeasurement also provided a good estimate of data precision. The target of plots to be remeasured was 10 percent or 21 forested plots; 31 forested plots (15.0 percent of the total forested plots) were remeasured during 1990 (Table 1). Two plots were remeasured twice during the field season for comparison between the two remeasurement crews. In all, 1,070 trees (14.8 percent of sample trees) were remeasured (Table 6).

Table 6.--Relative distribution of remeasured sample trees 5.0 inches or larger in d.b.h., by species, Forest Health Monitoring, New England, 1990

Species	Live	Dead	Total
	-------------	(percent)	-------------
Balsam fir	12.2	7.0	10.9
Red spruce	4.6	11.1	5.2
Eastern white pine	21.8	19.7	21.6
Eastern hemlock	23.0	18.2	22.9
Red maple	20.3	24.5	20.5
Sugar maple	12.9	10.3	12.8
Yellow birch	12.5	17.6	13.1
Paper birch	11.2	28.2	14.1
American beech	19.7	14.3	19.3
Aspen sp.	9.1	8.0	9.0
Northern red oak	39.9	66.7	40.3
Other	10.3	8.0	10.0
All Species	15.1	12.4	14.8

The remeasurement crew did not refer to the original values in order to obtain an unbiased estimate of measurement error. Accuracy could not be estimated because the "true" value is unknown. Measurement precision values were compared with target MQO's to identify problem areas with regard to methods, training, and implementation. The precision estimates were used to develop realistic MQO's for subsequent field seasons.

Data Quality Results and Discussion

The revision of the target MQO's was based on data collected during the remeasurement program (Table 7). The decision to revise the limits was based primarily on the 1990 data-quality performance, but also considered the potential data quality necessary for program objectives. In most cases, the limits were met for most variables. Variables with the worst performance were those that received the least coverage during the training session. Also, the methods manual has been improved for some of these variables .

Action items for the 1991 field season were those areas that needed to be addressed to improve data quality are shown in Table 8. Some of these items were based on comments from the training evaluation questionnaire and the debriefing of field crews.

Remeasurement of d.b.h. and crown dieback proved that the initial MQO's for these measurements were appropriate. Almost 95 percent of diameter remeasurements for trees 5.0, inches and larger in d.b.h. were within prescribed precision limits of + 0.2 inch (Figure 20). Crown dieback was remeasured within initial precision limits of + 10 percent (two dieback classes) more than 90 percent of the time (Figure 21).

Foliage transparency was remeasured less precisely, with 87 percent of the remeasurements within initial precision limits of + 10 percent (Figure 22). For some species, data-quality values are comparable to those from the North American Maple Decline Project (Millers et al. 1991). Data-quality problems were encountered for balsam fir (88.6 percent agreement between measurements), eastern white pine (71.2 percent), eastern hemlock (84.7 percent), and aspen species (68.4 percent). Three of these species are conifers, and only 19 aspen were remeasured. This low sample size partially explains the poor performance of that species.

Other crown measures for which data quality was poor were percent live crown and needle retention. Percent live crown was revised for the 1991 field season. Needle retention was especially poor for red spruce; only 75.8 percent of the remeasurements were + 4 years of the original measurement. A histogram of the deviations shows a bias towards longer needle retention in the remeasured values. This variable also needs to be reevaluated.

Data quality also was poor for terrain position, microrelief, landform type, plot disturbance, and plot uniformity (Table 7). These were primarily in the plot- and site-description group. Most of these variables were not addressed during the training session, but they can be corrected for the next field season because they will not change over time. These variables should be included in future training sessions.

Table 7. Remeasurement precision results and revised precision limits, Forest Health Monitoring, New England, 1990.

Variable	Units	Precision limits	% within limits	Revised precision limits
		Plot, Point, and Site Level Descriptions		
Land Use	NA	?	Not evaluated	90% agreement
Elevation	100 feet	± 100 ft.	Not evaluated	± 100 ft.
Slope	1 %	± 10%	84.9%	90% of values ± 10%
Aspect	degrees	± 15°	60.4%	90% of values ± 30°
Terrain Position	7 classes	?	48.8% agreement	90% agreement
Microrelief	4 classes	?	62.6% agreement	90% agreement
Landform Type	8 classes	?	63.4% agreement	90% agreement
Plot Disturbance	6 classes	?	75.6% agreement	90% agreement
Plot Uniformity	6 classes	?	NA	NA
Forest Type	9 groups (60+ types)	?	Not evaluated	Unknown
		Plot Tree Measurements (>4.9 in. DBH)		
Species	NA	19 of 20 to genus (95%) 9 of 10 to species (90%) 95.5%	99.0% 90% to species	95% to genus
Tree Location:				
Distance	0.1 ft.	± 0.5 ft.	87.0%	90% of values ± 0.5 ft.
Azimuth	degrees	± 2°	54.9%	90% of values ± 5°
Crown Position	6 classes	?	66.8% complete 96.5% acceptable	75% complete agreement 95% acceptable agreement
DBH	0.1 in.	± 0.2 in.	94.2%	95% of values ± 0.2 in.
% Live Crown	5% classes	+2 classes or +10%	73.1%	90% of values ±10%
Visual Symptoms:				
Crown Dieback	5% classes	± 2 classes or ± 10%	91.9%	90% of values ± 10%
Crown Transpar.	5% classes	± 2 classes or ± 10%	86.6%	90% of values ± 10%
Crown Disc.	5% classes	± 2 classes or ± 10%	99.1%	95% of values ± 5%
Needle Retention	years	Species dependent: Fir spp., ± 2 yrs.	94.9%	95% of values ± 2 years

		Spruce spp., ± 2 yrs.	57.6%	90% of values ± 2 years
		Pine spp., ± 1 yr.	98.7%	95% of values ± 1 year
Damage Evaluation(s):				
Description	NA	NA	NA	
Location	NA	NA	NA	
Probable Cause	NA	NA	NA	
		Sapling Measurements (1.0 to 4.9 in DBH)		
Species	NA	9 of 10 to genus (90%)	97.4%	95% to genus
		8 of 10 to species (80%)	91.8%	90% to species
Tree Location:				
Distance	0.1 ft.	± 0.2 ft.	74.8%	90% of values ± 0.4 ft.
Azimuth	degrees	± 2°	40.5%	90% of values ± 10°
Condition Class	4 classes	?	87.7% agreement	90% agreement
DBH	0.1 in.	±0.2 in.	93.9%	90% of values ± 0.2 in.
		Seedling and Percent Cover Measurements		
Seedling:				
Species	NA	9 of 10 to genus (90%)	Not evaluated	95% to genus
		8 of 10 to species (80%)	Not evaluated	90% to species
Number	number	?	80.9% ± 2	85% of values ± 2 individuals
Percent Cover Estimates:				
Mosses	5% classes	± 2 classes or ± 10%	80.5%	90% of values ± 20%
Ferns	5% classes	± 2 classes or ± 10%	86.2%	90% of values ± 20%
Herbaceous	5% classes	± 2 classes or ± 10%	71.5%	90% of values ± 20%
Shrubs	5% classes	± 2 classes or ± 10%	78.9%	90% of values ± 20%
		Plant Indicator for Air Pollution Symptoms		
Area Location:				
Distance	1 ft.	± 30 ft.	Not evaluated	± 30 ft.
Azimuth	degrees	± 10°	Not evaluated	± 10°
Species	NA	?	Not evaluated	?
Numbers	number	?	Not evaluated	90% of values ± 2 individuals

Table 8.--Summary of corrective action to improve data quality by measurment

Variable	Action for 1991
	Plot, Point, and Site Level Descriptions
Land use	Develop system to evaluate during remeasurement program.
Elevation	Develop system to evaluate during remeasurement program.
Slope	Minor adjustments to manual. Include test during training session.
Aspect	Revise manual and include calibration of compass instruction and testing during training session.
Terrain position, microrelief, landform type, plot disturbance, and plot uniformity	Major revision of manual and include instruction and testing during training session.
Forest type	No recommendation.
	Plot Tree Measurements (> 4.9 inches d.b.h.)
Species	No change.
Tree location:	
Distance	Minor change in manual to emphasize where to measure.
Azimuth	(See Aspect)
D.b.h.	No change.
Live crown (%)	Major revision of manual and include instruction and testing during training session.
Visual symptoms:	
Crown dieback	No change.
Crown transparency	Minor chnages in manual and emphasize problem species (balsam fir, eastern white pine, eastern hemlock, and aspen) during training session.
Crown discoloration	No change.
Needle retention	Reevaluate method and necessity of variable for next field season.
Damage evaluation	Reemphasize during training session.
	Sapling measurements (1.0 to 4.9 inches d.b.h.)
Species	No change.
Tree location:	
Distance	Reemphasize where to measure during training session and minor manual revisions
Azimuth	See Aspect.
D.b.h.	No change.
	Seedling and Percent Cover Estimates
Species	No recommendations.
Number	Include testing during training.
Cover estimates (%):	
Mosses, ferns, shrubs, and herbaceous	Short instruction of differentiation of herbaceous and shrubs type groups during training and include testing.
	Plant Indicator for Air Pollution Symptoms
All variables	Develop measurement system to evaluate data quality, minor change in manual, and refresher course during training session.

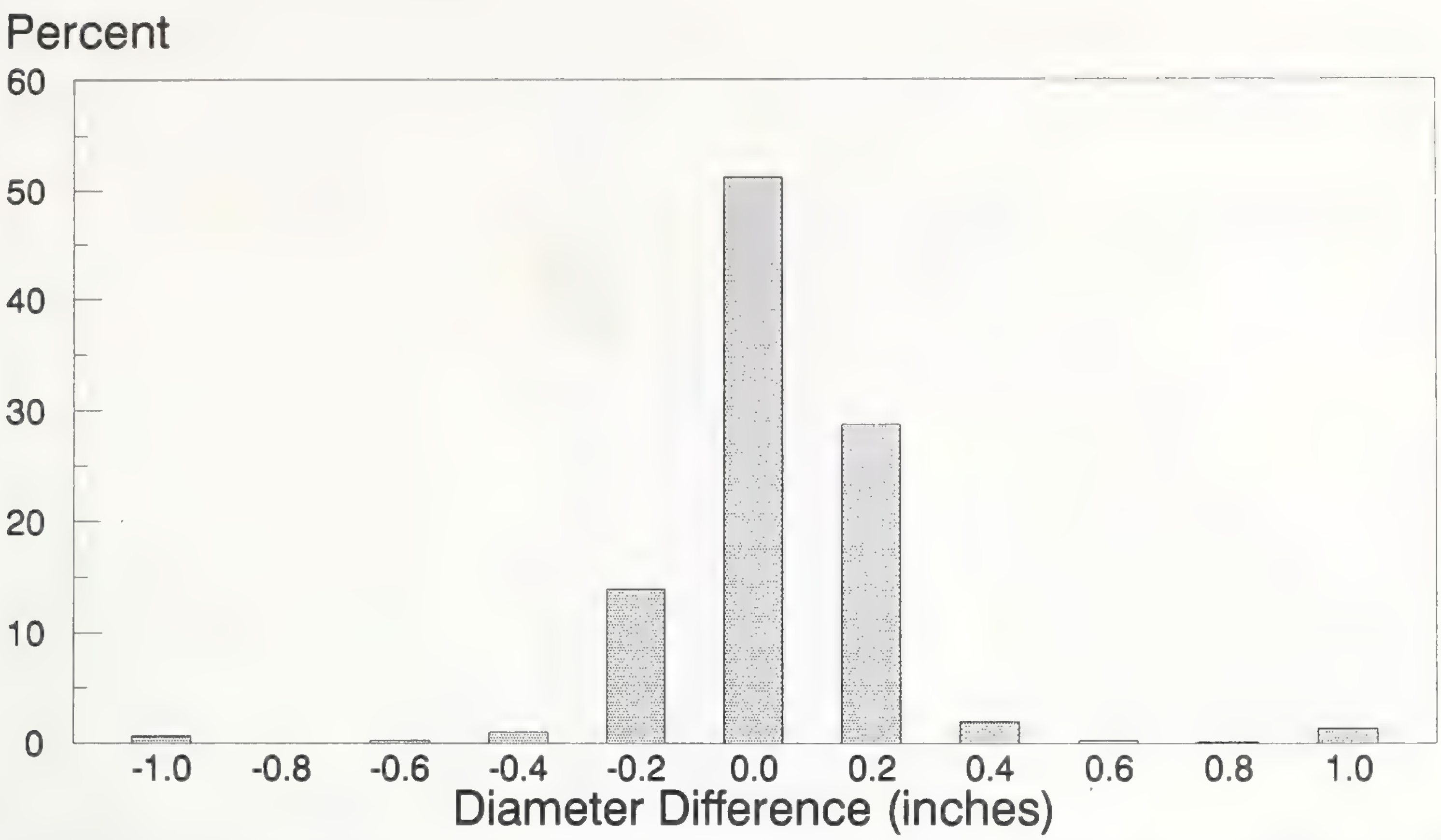

Figure 20.--Distribution of deviations between initial and remeasured d.b.h. on FHM plots, New England, 1990.

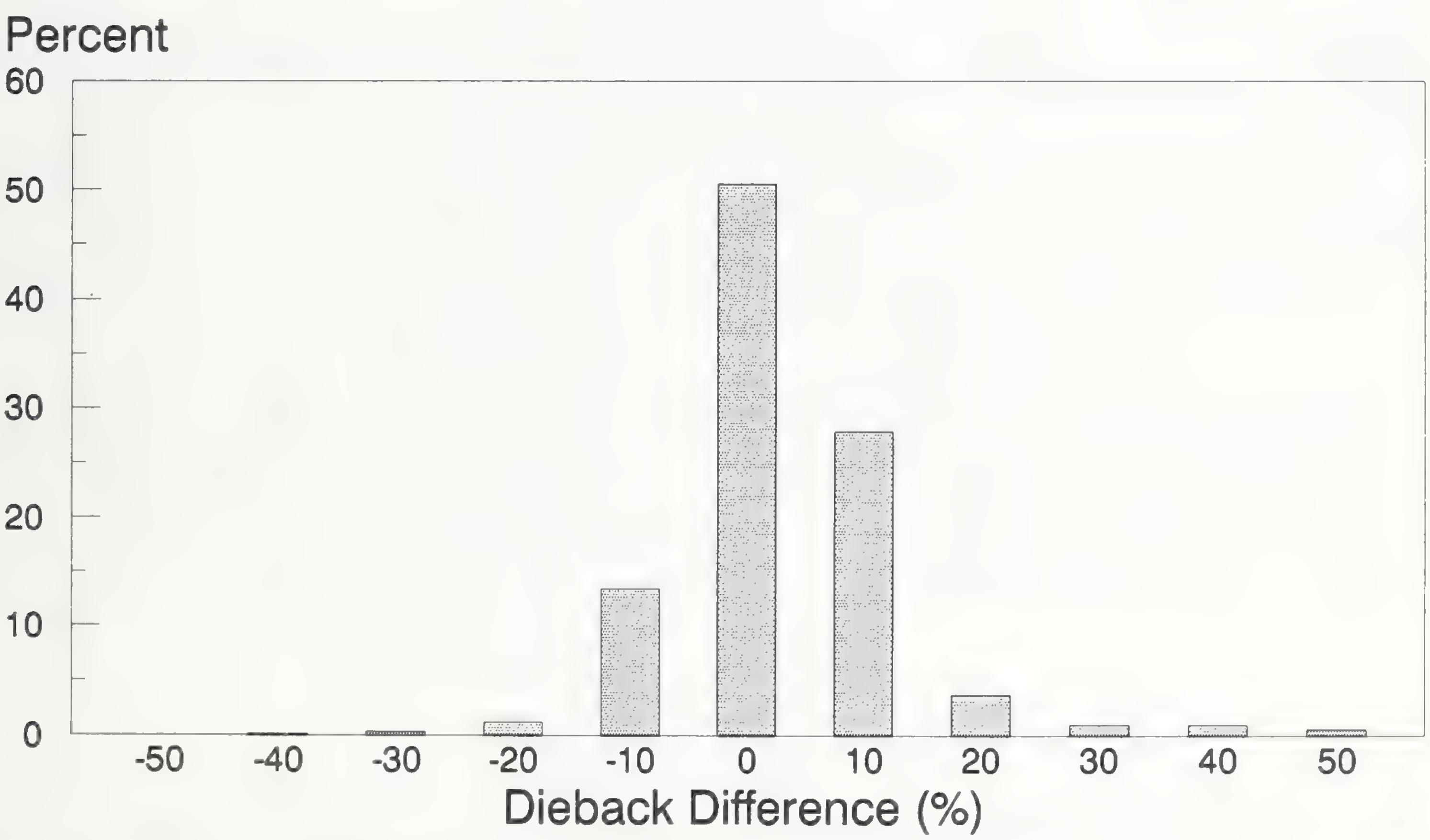

Figure 21.--Distribution of deviations between initial and remeasured crown dieback on FHM plots, New England, 1990.

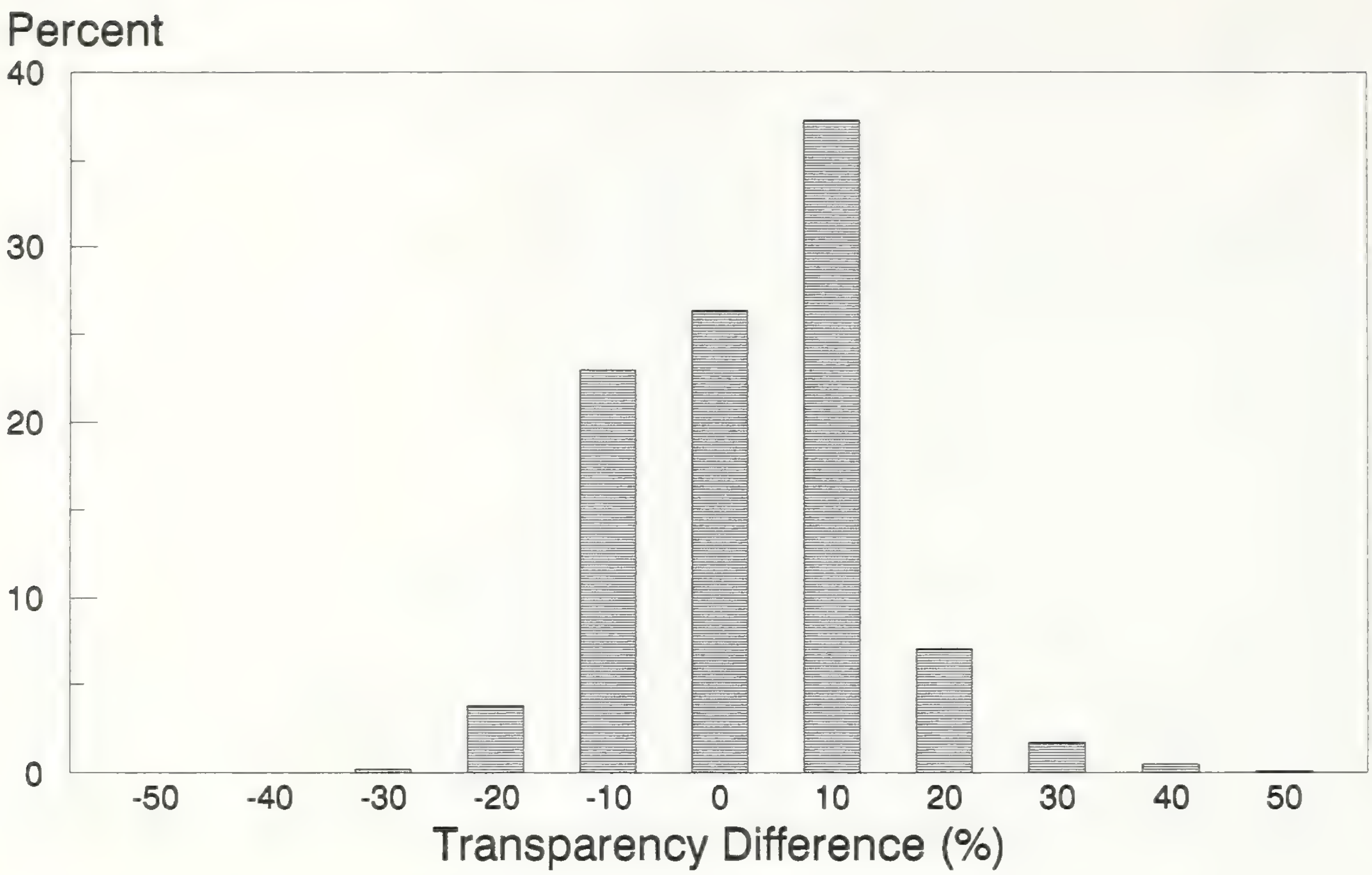

Figure 22.--Distribution of deviations between initial and remeasured transparency on FHM plots, New England, 1990.

Recommendations for Next Field Season

Decisions on altering methodology should be based on information collected from the training session, audits, crew debriefing, and the remeasurement program.

1. Methods manual. The manual needs to be revised for the next field season. The revision should include new or modified variables and new sections on the relocation of plots and trees on plots. A pocket-sized version of the manual also should be developed and should include at a minimum data codes and definitions. Because the field crews have the most familiarity with methods implementation, they should be involved in the revision of the manual.

2. Training. Of the many concerns expressed about the training session, most centered around the amount of field work. Because many of the field crew personnel will be returning, it probably will be necessary to conduct a two-level training session, though all individuals will attend a review of current methodology that incorporates both new variables and those that have been modified. Also, all individuals should participate in the testing/evaluation of training, the use of "expert" instructors should continue, and there should be more field training and less classroom instruction.

3. Audits. The audit program should include more individuals from the technical committee; this will require basic training in auditing procedures. All field crews should be visited early in the field season (i.e., within 2 weeks of the end of training) to ensure that methods are being implemented correctly. Visits with new personnel should have top priority. These audits can be used to answer questions, identify problem areas, and possibly determine corrective actions. They should be conducted by members of the technical committee instructors, QA personnel, and members of the remeasurement crew(s). A short (fewer than two pages), written report should be filed with the QA personnel that can be used to document problems encountered during the "off season".

4. Remeasurement program. The remeasurement program needs to be adjusted so that areas that were not evaluated, primarily the air pollution indicator-plant group and any new measurements added in 1991, can be addressed. These areas have no data-quality estimates because the remeasurement crew had no access to the original crews' information. Data transfer needs to be accelerated for both original and remeasurement data so that early evaluations of data quality can be made.

5. Scheduling. The scheduling of plot measurements during the field season also needs to be addressed. Becasue many of the measurements are seasonally variable, plots should be measured as closely as possible to the same period as when they were measured in 1990. The guidelines should be general to accommodate field logistics, but early plots should be measured early and late plots should be measured late.

Index to Forest Health Monitoring tables, New England, 1990

Table 9.--Number of plots by land class and state or region.

Land class	States				All states
	Maine	New Hampshire	Vermont	S. New England	
Timberland	108	33	21	28	190
Urban timberland	1	0	2	1	4
Total timberland	109	33	23	29	194
Noncommercial forest land					
Productive reserved	5	0	1	1	7
Unproductive reserved	1	0	0	0	1
Unproductive	2	0	0	0	2
Total noncommercial	8	0	1	1	10
All forest plots	117	33	24	30	204
Cropland	3	0	3	1	7
Improved pasture	1	0	3	3	7
Idle farmland	1	0	0	1	2
Other farmland	0	0	2	0	2
Bog/marsh/swamp	1	1	0	3	5
Rights-of-way	6	1	0	2	9
Maintained recreation site	1	0	0	1	2
Industrial,commercial land	1	0	0	4	5
Multiple family housing	1	1	1	0	3
Single family housing	1	0	2	6	9
Other land	3	1	0	0	4
Noncensus water	0	0	0	2	2
Total nonforest	19	4	11	23	57
All plots	136	37	35	53	261

Table 10.--Number of plots by forest-type group and stand-size class.

Forest-type group	Stand-size class				All classes
	Saw-timber	Pole-timber	Sapling and seedling	Non-stocked	
White/red pine	26	6	2	0	34
Spruce/fir	20	23	13	0	56
Oak/pine	3	7	0	0	10
Oak/hickory	12	4	1	0	17
Elm/ash/red maple	1	3	2	0	6
Northern hardwoods	36	19	15	0	70
Aspen/birch	0	7	4	0	11
All groups	98	69	37	0	204

Table 11.--Number of sample trees by detailed species and tree-size class, all forest-type groups.

Species	Tree-size class					All classes
	Seedling/ saplings	Poletimber	Sawtimber	All 5.0"+	Dead 5.0"+	
Balsam fir	3,378	550	96	646	228	4,252
Eastern redcedar	6	4	0	4	5	15
Larch (introduced)	8	7	1	8	1	17
Tamarack (native)	6	7	3	10	7	23
Norway spruce	12	5	1	6	0	18
White spruce	45	50	21	71	8	124
Black spruce	144	27	2	29	9	182
Blue spruce	0	2	0	2	0	2
Red spruce	665	487	224	711	63	1,439
Red pine	2	3	11	14	0	16
Pitch pine	0	2	2	4	0	4
White pine	218	400	316	716	71	1,005
Northern white-cedar	309	216	142	358	32	699
Eastern hemlock	293	249	177	426	11	730
All softwoods	5,086	2,009	996	3,005	435	8,526
Maple species	6	0	0	0	0	6
Striped maple	815	26	0	26	6	847
Red maple	1,618	891	140	1,031	49	2,698
Silver maple	0	1	1	2	0	2
Sugar maple	1,543	353	134	487	29	2,059
Mountain maple	124	0	0	0	0	124
Tree-of-heaven	1	0	0	0	0	1
Serviceberry	15	0	0	0	0	15
Yellow birch	388	210	62	272	34	694
Sweet birch	140	69	14	83	3	226
River birch	3	0	0	0	1	4
Paper birch	664	299	39	338	39	1,041
Gray birch	149	46	3	49	14	212
American hornbeam	86	19	0	19	0	105
Hickory species	3	0	1	1	0	4
Bitternut hickory	2	0	0	0	0	2
Pignut hickory	20	36	7	43	1	64
Shagbark hickory	5	18	0	18	0	23
American chestnut	4	0	0	0	0	4
Flowering dogwood	14	0	0	0	0	14
Beech	505	216	48	264	21	790
White ash	565	136	39	175	8	748
Black ash	42	20	2	22	2	66
Green ash	33	18	3	21	0	54
American holly	3	0	0	0	0	3
Butternut	0	2	0	2	0	2

Table 11.--continued

Species	Tree-size class					All classes
	Seedling/ saplings	Poletimber	Sawtimber	All 5.0"+	Dead 5.0"+	
Tulip-poplar	3	5	1	6	0	9
Apple species	10	6	0	6	0	16
Blackgum	4	5	0	5	0	9
Eastern hophornbeam	148	18	1	19	2	169
Balsam poplar	21	7	2	9	1	31
Eastern cottonwood	0	1	2	3	0	3
Bigtooth aspen	15	30	16	46	4	65
Quaking aspen	141	136	27	163	21	325
Pin cherry	96	5	0	5	4	105
Black cherry	366	36	8	44	10	420
Choke cherry	34	0	0	0	0	34
White oak	77	16	18	34	10	121
Swamp white oak	0	0	1	1	0	1
Scarlet oak	0	10	5	15	1	16
Blackjack oak	0	1	0	1	0	1
Pin oak	0	0	1	1	0	1
Chestnut oak	19	11	1	12	13	44
Northern red oak	264	133	55	188	3	455
Black oak	16	19	23	42	2	60
Willow species	35	0	0	0	0	35
Black willow	25	0	0	0	0	25
Sassafras	14	0	0	0	0	14
American mountain-ash	25	0	0	0	0	25
American basswood	25	10	2	12	0	37
Elm species	10	0	0	0	0	10
American elm	51	5	2	7	17	75
Slippery elm	1	1	1	2	1	4
Unknown	49	1	1	2	4	55
All hardwoods	8,197	2,816	660	3,476	300	11,973
All species	13,283	4,825	1,656	6,481	735	20,499

Table 12.--Number of sample trees by detailed species and tree-size class, White Pine forest-type group.

Species	Tree-size class					All classes
	Seedling/ saplings	Poletimber	Sawtimber	All 5.0"+	Dead 5.0"+	
Balsam fir	266	37	6	43	3	312
Eastern redcedar	0	1	0	1	4	5
Tamarack (native)	0	3	0	3	0	3
Norway spruce	1	5	1	6	0	7
White spruce	10	6	1	7	0	17
Black spruce	12	1	0	1	0	13
Red spruce	47	72	22	94	4	145
Red pine	2	3	9	12	0	14
Pitch pine	0	2	2	4	0	4
White pine	140	313	222	535	45	720
Northern white-cedar	1	6	1	7	2	10
Eastern hemlock	135	121	101	222	9	366
All softwoods	614	570	365	935	67	1,616
Striped maple	79	1	0	1	0	80
Red maple	123	119	12	131	1	255
Sugar maple	53	12	4	16	2	71
Yellow birch	16	13	3	16	2	34
Sweet birch	0	13	1	14	0	14
Paper birch	76	29	3	32	6	114
Gray birch	15	8	0	8	2	25
American hornbeam	30	1	0	1	0	31
Hickory species	1	0	1	1	0	2
Pignut hickory	0	2	0	2	0	2
Shagbark hickory	1	1	0	1	0	2
Flowering dogwood	4	0	0	0	0	4
Beech	62	22	5	27	0	89
White ash	144	21	2	23	0	167
Apple species	2	0	0	0	0	2
Eastern hophornbeam	1	0	0	0	0	1
Eastern cottonwood	0	1	2	3	0	3
Bigtooth aspen	5	11	5	16	1	22
Quaking aspen	42	56	5	61	6	109
Pin cherry	17	1	0	1	0	18
Black cherry	60	5	2	7	4	71
Choke cherry	4	0	0	0	0	4
White oak	5	1	5	6	1	12
Scarlet oak	0	1	1	2	0	2
Northern red oak	41	23	3	26	1	68
Black oak	4	12	4	16	0	20
Willow species	26	0	0	0	0	26
American elm	44	1	1	2	5	51
Unknown	1	0	0	0	0	1
All hardwoods	856	354	59	413	31	1,300
All species	1,470	924	424	1,348	98	2,916

Table 13.--Number of sample trees by detailed species and tree-size class, Spruce/fir forest-type group.

Species	Tree-size class					All classes
	Seedling/ saplings	Poletimber	Sawtimber	All 5.0"+	Dead 5.0"+	
Balsam fir	2,160	377	71	448	181	2,789
Eastern redcedar	0	0	0	0	1	1
Larch (introduced)	8	7	1	8	1	17
Tamarack (native)	6	3	3	6	4	16
Norway spruce	11	0	0	0	0	11
White spruce	28	34	17	51	3	82
Black spruce	132	25	2	27	8	167
Blue spruce	0	2	0	2	0	2
Red spruce	427	351	173	524	43	994
White pine	4	8	15	23	2	29
Northern white-cedar	257	185	130	315	23	595
Eastern hemlock	21	11	14	25	0	46
All softwoods	3,054	1,003	426	1,429	266	4,749
Striped maple	104	4	0	4	1	109
Red maple	413	169	15	184	4	601
Sugar maple	239	13	6	19	1	259
Mountain maple	26	0	0	0	0	26
Serviceberry	3	0	0	0	0	3
Yellow birch	84	34	11	45	4	133
Paper birch	209	100	4	104	12	325
Gray birch	18	13	0	13	3	34
Flowering dogwood	2	0	0	0	0	2
Beech	35	19	4	23	6	64
White ash	15	8	0	8	1	24
Black ash	16	15	0	15	2	33
Green ash	8	5	0	5	0	13
Apple species	0	4	0	4	0	4
Eastern hophornbeam	5	4	1	5	0	10
Balsam poplar	21	7	2	9	1	31
Bigtooth aspen	0	2	1	3	0	3
Quaking aspen	63	32	5	37	5	105
Pin cherry	21	1	0	1	0	22
Black cherry	17	10	0	10	0	27
Choke cherry	23	0	0	0	0	23
Northern red oak	3	0	0	0	0	3
Willow species	9	0	0	0	0	9
Black willow	16	0	0	0	0	16
American mountain-ash	16	0	0	0	0	16
American elm	0	1	0	1	3	4
Unknown	34	1	0	1	0	35
All hardwoods	1,400	442	49	491	43	1,934
All species	4,454	1,445	475	1,920	309	6,683

Table 14.--Number of sample trees by detailed species and tree-size class, Oak/hickory forest-type group.

Species	Tree-size class					All classes
	Seedling/ saplings	Poletimber	Sawtimber	All 5.0"+	Dead 5.0"+	
Balsam fir	16	1	0	1	0	17
Eastern redcedar	5	3	0	3	0	8
Red spruce	2	0	0	0	0	2
White pine	7	14	10	24	3	34
Eastern hemlock	2	26	7	33	1	36
All softwoods	32	44	17	61	4	97
Striped maple	104	1	0	1	0	105
Red maple	106	60	25	85	3	194
Sugar maple	9	21	3	24	6	39
Serviceberry	1	0	0	0	0	1
Yellow birch	59	13	2	15	1	75
Sweet birch	121	26	5	31	1	153
River birch	0	0	0	0	1	1
Paper birch	6	10	1	11	4	21
Gray birch	0	1	2	3	0	3
American hornbeam	27	0	0	0	0	27
Hickory species	1	0	0	0	0	1
Pignut hickory	14	27	3	30	1	45
Shagbark hickory	3	13	0	13	0	16
American chestnut	4	0	0	0	0	4
Flowering dogwood	4	0	0	0	0	4
Beech	37	22	3	25	2	64
White ash	28	12	11	23	3	54
Black ash	0	0	1	1	0	1
Tulip-poplar	0	3	0	3	0	3
Blackgum	4	2	0	2	0	6
Eastern hophornbeam	93	2	0	2	0	95
Bigtooth aspen	0	1	0	1	0	1
Quaking aspen	2	3	0	3	0	5
Black cherry	47	0	0	0	0	47
Choke cherry	6	0	0	0	0	6
White oak	45	12	11	23	9	77
Swamp white oak	0	0	1	1	0	1
Scarlet oak	0	9	4	13	1	14
Pin oak	0	0	1	1	0	1
Northern red oak	55	36	31	67	2	124
Black oak	12	7	18	25	2	39
Sassafras	13	0	0	0	0	13
American basswood	7	0	0	0	0	7
American elm	1	0	1	1	0	2
Slippery elm	1	0	0	0	0	1
Unknown	0	0	0	0	3	3
All hardwoods	810	281	123	404	39	1,253
All species	842	325	140	465	43	1,350

Table 15.--Number of sample trees by detailed species and tree-size class, Northern hardwoods forest-type group.

Species	Tree-size class					All classes
	Seedling/ saplings	Poletimber	Sawtimber	All 5.0"+	Dead 5.0"+	
Balsam fir	707	90	16	106	37	850
Eastern redcedar	1	0	0	0	0	1
White spruce	3	7	2	9	4	16
Black spruce	0	0	0	0	1	1
Red spruce	162	48	24	72	14	248
White pine	40	39	26	65	15	120
Northern white-cedar	37	23	10	33	7	77
Eastern hemlock	133	85	53	138	1	272
All softwoods	1,083	292	131	423	79	1,585
Striped maple	424	17	0	17	2	443
Red maple	717	325	74	399	30	1,146
Silver maple	0	1	1	2	0	2
Sugar maple	1,137	288	120	408	20	1,565
Mountain maple	98	0	0	0	0	98
Yellow birch	223	127	45	172	23	418
Sweet birch	14	27	8	35	2	51
River birch	3	0	0	0	0	3
Paper birch	174	79	14	93	7	274
Gray birch	71	23	0	23	2	96
American hornbeam	24	16	0	16	0	40
Bitternut hickory	2	0	0	0	0	2
Pignut hickory	3	5	3	8	0	11
Shagbark hickory	1	4	0	4	0	5
Flowering dogwood	1	0	0	0	0	1
Beech	348	136	36	172	12	532
White ash	254	73	23	96	2	352
Black ash	17	5	1	6	0	23
Green ash	18	2	2	4	0	22
American holly	3	0	0	0	0	3
Butternut	0	1	0	1	0	1
Tulip-poplar	3	2	1	3	0	6
Apple species	0	1	0	1	0	1
Eastern hophornbeam	49	12	0	12	2	63
Bigtooth aspen	6	1	4	5	0	11
Quaking aspen	28	20	12	32	8	68
Pin cherry	58	3	0	3	4	65
Black cherry	186	10	5	15	6	207
White oak	8	0	1	1	0	9
Blackjack oak	0	1	0	1	0	1
Northern red oak	110	32	9	41	0	151
Black willow	8	0	0	0	0	8
American mountain-ash	4	0	0	0	0	4
American basswood	16	10	2	12	0	28
American elm	3	3	0	3	4	10
Unknown	14	0	1	1	1	16
All hardwoods	4,025	1,224	362	1,586	125	5,736
All species	5,108	1,516	493	2,009	204	7,321

Table 16.--Number of sample trees by detailed species and tree-size class, other forest-type groups.

Species	Tree-size class					All classes
	Seedling/ saplings	Poletimber	Sawtimber	All 5.0"+	Dead 5.0"+	
Balsam fir	229	45	3	48	7	284
Tamarack (native)	0	1	0	1	3	4
White spruce	4	3	1	4	1	9
Black spruce	0	1	0	1	0	1
Red spruce	27	16	5	21	2	50
Red pine	0	0	2	2	0	2
White pine	27	26	43	69	6	102
Northern white-cedar	14	2	1	3	0	17
Eastern hemlock	2	6	2	8	0	10
All softwoods	303	100	57	157	19	479
Maple species	6	0	0	0	0	6
Striped maple	104	3	0	3	3	110
Red maple	259	218	14	232	11	502
Sugar maple	105	19	1	20	0	125
Tree-of-heaven	1	0	0	0	0	1
Serviceberry	11	0	0	0	0	11
Yellow birch	6	23	1	24	4	34
Sweet birch	5	3	0	3	0	8
Paper birch	199	81	17	98	10	307
Gray birch	45	1	1	2	7	54
American hornbeam	5	2	0	2	0	7
Hickory species	1	0	0	0	0	1
Pignut hickory	3	2	1	3	0	6
Flowering dogwood	3	0	0	0	0	3
Beech	23	17	0	17	1	41
White ash	124	22	3	25	2	151
Black ash	9	0	0	0	0	9
Green ash	7	11	1	12	0	19
Butternut	0	1	0	1	0	1
Apple species	8	1	0	1	0	9
Blackgum	0	3	0	3	0	3
Bigtooth aspen	4	15	6	21	3	28
Quaking aspen	6	25	5	30	2	38
Black cherry	56	11	1	12	0	68
Choke cherry	1	0	0	0	0	1
White oak	19	3	1	4	0	23
Chestnut oak	19	11	1	12	13	44
Northern red oak	55	42	12	54	0	109
Black oak	0	0	1	1	0	1
Black willow	1	0	0	0	0	1
Sassafras	1	0	0	0	0	1
American mountain-ash	5	0	0	0	0	5
American basswood	2	0	0	0	0	2
Elm species	10	0	0	0	0	10
American elm	3	0	0	0	5	8
Slippery elm	0	1	1	2	1	3
All hardwoods	1,106	515	67	582	62	1,750
All species	1,409	615	124	739	81	2,229

Table 17.--Number of all-live sample trees by major species and diameter class, all forest-type groups.

Species	Diameter class (inches at breast height)									
	Seedlings	1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9
Balsam fir	3,021	276	81	372	178	68	20	6	1	1
Tamarack	1	8	5	11	3	3	1	0	0	0
White spruce	28	13	4	30	20	13	3	3	1	1
Black spruce	78	55	11	23	4	1	0	0	1	0
Red spruce	536	100	29	284	203	117	63	29	6	5
Red pine	2	0	0	1	2	2	3	2	3	0
Pitch pine	0	0	0	0	2	1	1	0	0	0
White pine	173	23	22	219	181	110	59	57	35	22
Northern white-cedar	277	21	11	105	111	71	32	23	9	4
Hemlock	226	47	20	159	90	66	55	24	18	6
Other softwoods	16	2	0	7	4	1	0	0	0	0
All softwoods	4,358	545	183	1,211	798	453	237	144	74	39
Red maple	1,384	179	55	433	277	181	72	33	16	12
Sugar maple	1,449	64	30	147	128	78	58	26	23	13
Yellow birch	331	54	3	94	77	39	20	19	18	3
Sweet birch	123	16	1	39	20	10	6	3	3	1
Paper birch	601	45	18	152	98	49	25	11	2	1
Gray birch	109	20	20	41	3	2	0	3	0	0
Hickory	23	5	2	24	20	10	3	2	3	0
Beech	423	58	24	112	61	43	27	9	7	2
White ash	517	38	10	76	39	21	20	10	4	1
Black ash	36	4	2	10	5	5	0	2	0	0
Aspen	164	8	5	91	40	43	26	15	3	2
Black cherry	337	23	6	16	15	5	3	5	0	0
White oaks	88	6	2	8	13	6	12	6	1	0
Northern red oak	230	24	10	35	52	46	19	16	6	7
Other red oaks	16	0	0	10	10	10	7	11	6	0
Elm	59	3	0	3	3	0	1	0	1	0
Other hardwoods	1,395	149	28	86	23	7	2	2	3	2
All hardwoods	7,285	696	216	1,377	884	555	301	173	96	44
All species	11,643	1,241	399	2,588	1,682	1,008	538	317	170	83

Table 17.--continued

Species	Diameter class (inches at breast height)				
	19.0-20.9	21.0-28.9	29.0+	Total 5.0+	All classes
Balsam fir	0	0	0	646	4,024
Tamarack	0	0	0	18	32
White spruce	0	0	0	71	116
Black spruce	0	0	0	29	173
Red spruce	1	3	0	711	1,376
Red pine	1	0	0	14	16
Pitch pine	0	0	0	4	4
White pine	11	20	2	716	934
Northern white-cedar	1	2	0	358	667
Hemlock	5	3	0	426	719
Other softwoods	0	0	0	12	30
All softwoods	19	28	2	3,005	8,091
Red maple	3	3	1	1,031	2,649
Sugar maple	5	6	3	487	2,030
Yellow birch	1	0	1	272	660
Sweet birch	1	0	0	83	223
Paper birch	0	0	0	338	1,002
Gray birch	0	0	0	49	198
Hickory	0	0	0	62	92
Beech	2	1	0	264	769
White ash	3	1	0	175	740
Black ash	0	0	0	22	64
Aspen	1	0	0	221	398
Black cherry	0	0	0	44	410
White oaks	0	1	0	47	143
Northern red oak	3	2	2	188	452
Other red oaks	4	0	1	59	75
Elm	0	1	0	9	71
Other hardwoods	0	0	0	125	1,697
All hardwoods	23	15	8	3,476	11,673
All species	42	43	10	6,481	19,764

Table 18.--Number of all-live sample trees by major species and diameter class, White pine forest-type group.

Species	Diameter class (inches at breast height)									
	Seedlings	1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9
Balsam fir	226	30	10	30	7	4	2	0	0	0
Tamarack	0	0	0	1	2	0	0	0	0	0
White spruce	10	0	0	4	2	1	0	0	0	0
Black spruce	6	6	0	1	0	0	0	0	0	0
Red spruce	34	8	5	45	27	13	4	3	1	1
Red pine	2	0	0	1	2	2	3	1	2	0
Pitch pine	0	0	0	0	2	1	1	0	0	0
White pine	114	8	18	173	140	77	43	33	24	17
Northern white-cedar	0	0	1	5	1	1	0	0	0	0
Hemlock	97	25	13	79	42	38	26	16	10	5
Other softwoods	0	1	0	4	2	1	0	0	0	0
All softwoods	489	78	47	343	227	138	79	53	37	23
Red maple	105	12	6	59	36	24	6	5	1	0
Sugar maple	42	8	3	3	7	2	1	3	0	0
Yellow birch	15	1	0	6	5	2	0	3	0	0
Sweet birch	0	0	0	5	5	3	1	0	0	0
Paper birch	74	0	2	23	3	3	1	2	0	0
Gray birch	5	7	3	7	0	1	0	0	0	0
Hickory	2	0	0	1	2	0	0	1	0	0
Beech	55	6	1	12	5	5	4	1	0	0
White ash	132	12	0	11	4	6	2	0	0	0
Black ash	0	0	0	0	0	0	0	0	0	0
Aspen	41	3	3	47	12	9	7	3	1	1
Black cherry	57	3	0	2	1	2	1	1	0	0
White oaks	5	0	0	0	1	0	2	3	0	0
Northern red oak	35	3	3	4	12	7	2	0	1	0
Other red oaks	4	0	0	5	3	5	3	0	1	0
Elm	43	1	0	0	1	0	1	0	0	0
Other hardwoods	147	16	1	3	0	0	0	0	0	0
All hardwoods	762	72	22	188	97	69	31	22	4	1
All species	1,251	150	69	531	324	207	110	75	41	24

Table 18.--continued

Species	Diameter class (inches at breast height)				
	19.0-20.9	21.0-28.9	29.0+	Total 5.0+	All classes
Balsam fir	0	0	0	43	309
Tamarack	0	0	0	3	3
White spruce	0	0	0	7	17
Black spruce	0	0	0	1	13
Red spruce	0	0	0	94	141
Red pine	1	0	0	12	14
Pitch pine	0	0	0	4	4
White pine	9	17	2	535	675
Northern white-cedar	0	0	0	7	8
Hemlock	4	2	0	222	357
Other softwoods	0	0	0	7	8
All softwoods	14	19	2	935	1,549
Red maple	0	0	0	131	254
Sugar maple	0	0	0	16	69
Yellow birch	0	0	0	16	32
Sweet birch	0	0	0	14	14
Paper birch	0	0	0	32	108
Gray birch	0	0	0	8	23
Hickory	0	0	0	4	6
Beech	0	0	0	27	89
White ash	0	0	0	23	167
Black ash	0	0	0	0	0
Aspen	0	0	0	80	127
Black cherry	0	0	0	7	67
White oaks	0	0	0	6	11
Northern red oak	0	0	0	26	67
Other red oaks	1	0	0	18	22
Elm	0	0	0	2	46
Other hardwoods	0	0	0	3	167
All hardwoods	1	0	0	413	1,269
All species	15	19	2	1,348	2,818

Table 19.--Number of all-live sample trees by major species and diameter class, Spruce/fir forest-type group.

Species	Diameter class (inches at breast height)									
	Seedlings	1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9
Balsam fir	1,961	148	51	244	133	51	15	4	1	0
Tamarack	1	8	5	9	1	3	1	0	0	0
White spruce	14	11	3	20	14	11	3	2	0	1
Black spruce	72	49	11	22	3	1	0	0	1	0
Red spruce	349	61	17	200	151	93	49	21	4	3
White pine	3	1	0	4	4	4	3	4	2	1
Northern white-cedar	234	16	7	85	100	64	31	21	9	3
Hemlock	21	0	0	4	7	3	3	4	3	0
Other softwoods	11	0	0	1	1	0	0	0	0	0
All softwoods	2,666	294	94	589	414	230	105	56	20	8
Red maple	373	29	11	92	46	31	8	5	1	1
Sugar maple	229	8	2	4	2	7	2	1	1	2
Yellow birch	71	11	2	15	11	8	2	3	5	1
Sweet birch	0	0	0	0	0	0	0	0	0	0
Paper birch	184	20	5	52	37	11	2	2	0	0
Gray birch	11	2	5	12	0	1	0	0	0	0
Hickory	0	0	0	0	0	0	0	0	0	0
Beech	27	4	4	18	1	0	3	1	0	0
White ash	8	6	1	6	2	0	0	0	0	0
Black ash	15	0	1	6	4	5	0	0	0	0
Aspen	82	1	1	17	12	12	3	4	1	0
Black cherry	14	2	1	6	4	0	0	0	0	0
White oaks	0	0	0	0	0	0	0	0	0	0
Northern red oak	3	0	0	0	0	0	0	0	0	0
Elm	0	0	0	1	0	0	0	0	0	0
Other hardwoods	237	28	2	16	2	1	0	0	1	0
All hardwoods	1,254	111	35	245	121	76	20	16	9	4
All species	3,920	405	129	834	535	306	125	72	29	12

Table 19.--continued

Species	Diameter class (inches at breast height)				
	19.0-20.9	21.0-28.9	29.0+	Total 5.0+	All classes
Balsam fir	0	0	0	448	2,608
Tamarack	0	0	0	14	28
White spruce	0	0	0	51	79
Black spruce	0	0	0	27	159
Red spruce	0	3	0	524	951
White pine	1	0	0	23	27
Northern white-cedar	1	1	0	315	572
Hemlock	0	1	0	25	46
Other softwoods	0	0	0	2	13
All softwoods	2	5	0	1,429	4,483
Red maple	0	0	0	184	597
Sugar maple	0	0	0	19	258
Yellow birch	0	0	0	45	129
Sweet birch	0	0	0	0	0
Paper birch	0	0	0	104	313
Gray birch	0	0	0	13	31
Hickory	0	0	0	0	0
Beech	0	0	0	23	58
White ash	0	0	0	8	23
Black ash	0	0	0	15	31
Aspen	0	0	0	49	133
Black cherry	0	0	0	10	27
White oaks	0	0	0	0	0
Northern red oak	0	0	0	0	3
Elm	0	0	0	1	1
Other hardwoods	0	0	0	20	287
All hardwoods	0	0	0	491	1,891
All species	2	5	0	1,920	6,374

Table 20.--Number of all-live sample trees by major species and diameter class, Oak/hickory forest-type group.

Species	Diameter class (inches at breast height)									
	Seedlings	1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9
Balsam fir	16	0	0	0	1	0	0	0	0	0
Tamarack	0	0	0	0	0	0	0	0	0	0
White spruce	0	0	0	0	0	0	0	0	0	0
Black spruce	0	0	0	0	0	0	0	0	0	0
Red spruce	2	0	0	0	0	0	0	0	0	0
Red pine	0	0	0	0	0	0	0	0	0	0
White pine	4	2	1	9	5	3	1	3	0	1
Northern white-cedar	0	0	0	0	0	0	0	0	0	0
Hemlock	0	1	1	18	8	3	3	0	1	0
Other softwoods	4	1	0	2	1	0	0	0	0	0
All softwoods	26	4	2	29	15	6	4	3	1	1
Red maple	79	21	6	23	21	16	12	5	4	2
Sugar maple	7	2	0	12	7	2	0	0	0	2
Yellow birch	55	4	0	10	2	1	1	0	1	0
Sweet birch	113	8	0	15	6	5	2	1	1	1
Paper birch	6	0	0	4	4	2	1	0	0	0
Gray birch	0	0	0	0	1	0	0	2	0	0
Hickory	13	4	1	19	14	7	1	1	1	0
Beech	25	6	6	14	8	0	2	0	1	0
White ash	28	0	0	7	3	2	6	2	2	0
Black ash	0	0	0	0	0	0	0	1	0	0
Aspen	1	1	0	1	0	3	0	0	0	0
Black cherry	43	4	0	0	0	0	0	0	0	0
White oaks	44	1	0	3	7	2	8	2	1	0
Northern red oak	41	8	6	14	10	12	6	12	1	6
Other red oaks	12	0	0	4	7	5	4	11	4	0
Elm	1	1	0	0	0	0	0	0	1	0
Other hardwoods	240	21	2	6	1	1	0	0	0	0
All hardwoods	708	81	21	132	91	58	43	37	17	11
All species	734	85	23	161	106	64	47	40	18	12

Table 20.--continued

Species	Diameter class (inches at breast height)				
	19.0-20.9	21.0-28.9	29.0+	Total 5.0+	All classes
Balsam fir	0	0	0	1	17
Tamarack	0	0	0	0	0
White spruce	0	0	0	0	0
Black spruce	0	0	0	0	0
Red spruce	0	0	0	0	2
Red pine	0	0	0	0	0
White pine	0	2	0	24	31
Northern white-cedar	0	0	0	0	0
Hemlock	0	0	0	33	35
Other softwoods	0	0	0	3	8
All softwoods	0	2	0	61	93
Red maple	0	2	0	85	191
Sugar maple	0	0	1	24	33
Yellow birch	0	0	0	15	74
Sweet birch	0	0	0	31	152
Paper birch	0	0	0	11	17
Gray birch	0	0	0	3	3
Hickory	0	0	0	43	61
Beech	0	0	0	25	62
White ash	1	0	0	23	51
Black ash	0	0	0	1	1
Aspen	0	0	0	4	6
Black cherry	0	0	0	0	47
White oaks	0	1	0	24	69
Northern red oak	3	1	2	67	122
Other red oaks	3	0	1	39	51
Elm	0	0	0	1	3
Other hardwoods	0	0	0	8	271
All hardwoods	7	4	4	404	1,214
All species	7	6	4	465	1,307

Table 21.--Number of all-live sample trees by major species and diameter class, Northern hardwoods forest-type group.

Species	Diameter class (inches at breast height)									
	Seedlings	1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9
Balsam fir	635	56	16	59	31	11	2	2	0	1
White spruce	1	1	1	4	3	1	0	0	1	0
Black spruce	0	0	0	0	0	0	0	0	0	0
Red spruce	128	28	6	28	20	8	9	4	1	1
Red pine	0	0	0	0	0	0	0	0	0	0
White pine	32	6	2	21	18	10	3	7	4	2
Northern white-cedar	33	1	3	13	10	5	1	2	0	1
Hemlock	106	21	6	54	31	21	22	4	4	1
Other softwoods	1	0	0	0	0	0	0	0	0	0
All softwoods	936	113	34	179	113	56	37	19	10	6
Red maple	619	75	23	136	117	72	39	15	8	8
Sugar maple	1,073	41	23	120	104	64	54	22	22	9
Yellow birch	187	35	1	53	48	26	16	13	12	2
Sweet birch	6	7	1	17	8	2	3	2	2	0
Paper birch	152	20	2	39	25	15	8	4	1	1
Gray birch	51	9	11	21	2	0	0	0	0	0
Hickory	4	1	1	3	3	3	2	0	1	0
Beech	295	41	12	62	39	35	18	7	6	2
White ash	232	15	7	41	20	12	10	8	1	1
Black ash	16	1	0	4	1	0	0	1	0	0
Aspen	31	3	0	7	8	6	9	6	1	0
Black cherry	168	13	5	4	4	2	2	3	0	0
White oaks	4	4	0	0	0	0	1	0	0	0
Northern red oak	101	8	1	9	11	12	4	1	4	0
Other red oaks	0	0	0	1	0	0	0	0	0	0
Elm	3	0	0	1	2	0	0	0	0	0
Other hardwoods	638	72	13	48	14	3	2	1	2	2
All hardwoods	3,580	345	100	566	406	252	168	83	60	25
All species	4,516	458	134	745	519	308	205	102	70	31

Table 21.--continued

Species	Diameter class (inches at breast height)				
	19.0-20.9	21.0-28.9	29.0+	Total 5.0+	All classes
Balsam fir	0	0	0	106	813
White spruce	0	0	0	9	12
Black spruce	0	0	0	0	0
Red spruce	1	0	0	72	234
Red pine	0	0	0	0	0
White pine	0	0	0	65	105
Northern white-cedar	0	1	0	33	70
Hemlock	1	0	0	138	271
Other softwoods	0	0	0	0	1
All softwoods	2	1	0	423	1,506
Red maple	3	0	1	399	1,116
Sugar maple	5	6	2	408	1,545
Yellow birch	1	0	1	172	395
Sweet birch	1	0	0	35	49
Paper birch	0	0	0	93	267
Gray birch	0	0	0	23	94
Hickory	0	0	0	12	18
Beech	2	1	0	172	520
White ash	2	1	0	96	350
Black ash	0	0	0	6	23
Aspen	0	0	0	37	71
Black cherry	0	0	0	15	201
White oaks	0	0	0	1	9
Northern red oak	0	0	0	41	151
Other red oaks	0	0	0	1	1
Elm	0	0	0	3	6
Other hardwoods	0	0	0	72	795
All hardwoods	14	8	4	1,586	5,611
All species	16	9	4	2,009	7,117

Table 22.--Number of all-live sample trees by major species and diameter class, other forest-type groups.

Species	Diameter class (inches at breast height)									
	Seedlings	1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9
Balsam fir	183	42	4	39	6	2	1	0	0	0
Tamarack	0	0	0	1	0	0	0	0	0	0
White spruce	3	1	0	2	1	0	0	1	0	0
Black spruce	0	0	0	0	1	0	0	0	0	0
Red spruce	23	3	1	11	5	3	1	1	0	0
Red pine	0	0	0	0	0	0	0	1	1	0
White pine	20	6	1	12	14	16	9	10	5	1
Northern white-cedar	10	4	0	2	0	1	0	0	0	0
Hemlock	2	0	0	4	2	1	1	0	0	0
Other softwoods	0	0	0	0	0	0	0	0	0	0
All softwoods	241	56	6	71	29	23	12	13	6	1
Red maple	208	42	9	123	57	38	7	3	2	1
Sugar maple	98	5	2	8	8	3	1	0	0	0
Yellow birch	3	3	0	10	11	2	1	0	0	0
Sweet birch	4	1	0	2	1	0	0	0	0	0
Paper birch	185	5	9	34	29	18	13	3	1	0
Gray birch	42	2	1	1	0	0	0	1	0	0
Hickory	4	0	0	1	1	0	0	0	1	0
Beech	21	1	1	6	8	3	0	0	0	0
White ash	117	5	2	11	10	1	2	0	1	0
Black ash	5	3	1	0	0	0	0	0	0	0
Aspen	9	0	1	19	8	13	7	2	0	1
Black cherry	55	1	0	4	6	1	0	1	0	0
White oaks	35	1	2	5	5	4	1	1	0	0
Northern red oak	50	5	0	8	19	15	7	3	0	1
Other red oaks	0	0	0	0	0	0	0	0	1	0
Elm	12	1	0	1	0	0	0	0	0	0
Other hardwoods	133	12	10	13	6	2	0	1	0	0
All hardwoods	981	87	38	246	169	100	39	15	6	3
All species	1,222	143	44	317	198	123	51	28	12	4

Table 22.--continued

Species	Diameter class (inches at breast height)				
	19.0-20.9	21.0-28.9	29.0+	Total 5.0+	All classes
Balsam fir	0	0	0	48	277
Tamarack	0	0	0	1	1
White spruce	0	0	0	4	8
Black spruce	0	0	0	1	1
Red spruce	0	0	0	21	48
Red pine	0	0	0	2	2
White pine	1	1	0	69	96
Northern white-cedar	0	0	0	3	17
Hemlock	0	0	0	8	10
Other softwoods	0	0	0	0	0
All softwoods	1	1	0	157	460
Red maple	0	1	0	232	491
Sugar maple	0	0	0	20	125
Yellow birch	0	0	0	24	30
Sweet birch	0	0	0	3	8
Paper birch	0	0	0	98	297
Gray birch	0	0	0	2	47
Hickory	0	0	0	3	7
Beech	0	0	0	17	40
White ash	0	0	0	25	149
Black ash	0	0	0	0	9
Aspen	1	0	0	51	61
Black cherry	0	0	0	12	68
White oaks	0	0	0	16	54
Northern red oak	0	1	0	54	109
Other red oaks	0	0	0	1	1
Elm	0	1	0	2	15
Other hardwoods	0	0	0	22	177
All hardwoods	1	3	0	582	1,688
All species	2	4	0	739	2,148

Table 23.--Number of all-live sample trees (5.0+ inches d.b.h.) by major species and crown class, all forest-type groups.

Species	Crown class					All classes
	Open-grown	Dominant	Codominant	Intermediate	Suppressed	
Balsam fir	2	40	320	183	101	646
Tamarack	0	4	9	4	1	18
White spruce	0	10	30	24	7	71
Black spruce	0	5	19	4	1	29
Red spruce	4	73	388	160	86	711
Red pine	0	4	8	2	0	14
Pitch pine	0	0	4	0	0	4
White pine	5	91	433	102	85	716
Northern white-cedar	0	16	182	126	34	358
Hemlock	1	17	124	110	174	426
Other softwoods	0	0	3	5	4	12
All softwoods	12	260	1,520	720	493	3,005
Red maple	5	49	745	171	61	1,031
Sugar maple	4	27	337	81	38	487
Yellow birch	0	14	199	42	17	272
Sweet birch	0	1	52	18	12	83
Paper birch	2	29	262	36	9	338
Gray birch	0	4	24	16	5	49
Hickory	0	1	37	16	8	62
Beech	1	9	149	55	50	264
White ash	2	10	124	28	11	175
Black ash	0	0	15	7	0	22
Aspen	1	55	150	12	3	221
Black cherry	0	1	33	9	1	44
White oaks	0	1	34	10	2	47
Northern red oak	0	12	154	16	6	188
Other red oaks	0	3	49	7	0	59
Elm	0	0	6	2	1	9
Other hardwoods	0	5	55	49	16	125
All hardwoods	15	221	2,425	575	240	3,476
All species	27	481	3,945	1,295	733	6,481

Table 24.--Number of all-live sample trees (5.0+ inches d.b.h.) by major species and crown class, White pine forest-type group.

Species	Crown class					All classes
	Open-grown	Dominant	Codominant	Intermediate	Suppressed	
Balsam fir	0	2	14	13	14	43
Tamarack	0	0	2	1	0	3
White spruce	0	0	6	1	0	7
Black spruce	0	0	1	0	0	1
Red spruce	0	2	41	30	21	94
Red pine	0	2	8	2	0	12
Pitch pine	0	0	4	0	0	4
White pine	3	72	352	67	41	535
Northern white-cedar	0	0	0	3	4	7
Hemlock	1	11	76	71	63	222
Other softwoods	0	0	2	2	3	7
All softwoods	4	89	506	190	146	935
Red maple	2	9	86	27	7	131
Sugar maple	0	0	10	6	0	16
Yellow birch	0	2	10	4	0	16
Sweet birch	0	1	10	1	2	14
Paper birch	0	2	25	5	0	32
Gray birch	0	0	4	4	0	8
Hickory	0	0	1	1	2	4
Beech	1	0	9	9	8	27
White ash	0	1	18	4	0	23
Aspen	0	19	59	2	0	80
Black cherry	0	1	4	2	0	7
White oaks	0	0	5	1	0	6
Northern red oak	0	0	23	3	0	26
Other red oaks	0	1	14	3	0	18
Elm	0	0	2	0	0	2
Other hardwoods	0	0	1	1	1	3
All hardwoods	3	36	281	73	20	413
All species	7	125	787	263	166	1,348

Table 25.--Number of sample trees (5.0+ inches d.b.h.) by major species and crown class, Spruce/fir forest-type group.

Species	Crown class					All classes
	Open-grown	Dominant	Codominant	Intermediate	Suppressed	
Balsam fir	1	32	260	112	43	448
Tamarack	0	4	6	3	1	14
White spruce	0	10	23	15	3	51
Black spruce	0	5	18	3	1	27
Red spruce	3	68	303	112	38	524
White pine	0	11	8	3	1	23
Northern white-cedar	0	15	172	107	21	315
Hemlock	0	5	13	5	2	25
Other softwoods	0	0	1	1	0	2
All softwoods	4	150	804	361	110	1,429
Red maple	0	13	144	25	2	184
Sugar maple	1	5	13	0	0	19
Yellow birch	0	5	32	5	3	45
Paper birch	0	11	85	7	1	104
Gray birch	0	1	8	4	0	13
Beech	0	0	14	6	3	23
White ash	0	1	4	1	2	8
Black ash	0	0	10	5	0	15
Aspen	1	12	34	1	1	49
Black cherry	0	0	9	1	0	10
Elm	0	0	1	0	0	1
Other hardwoods	0	0	14	5	1	20
All hardwoods	2	48	368	60	13	491
All species	6	198	1,172	421	123	1,920

Table 26.--Number of all-live sample trees (5.0+ inches d.b.h.) by major species and crown class, Oak/hickory forest-type group.

Species	Crown class					All classes
	Open-grown	Dominant	Codominant	Intermediate	Suppressed	
Balsam fir	0	0	0	1	0	1
White pine	0	3	9	3	9	24
Hemlock	0	0	2	6	25	33
Other softwoods	0	0	0	2	1	3
All softwoods	0	3	11	12	35	61
Red maple	0	0	52	17	16	85
Sugar maple	1	1	14	2	6	24
Yellow birch	0	0	8	4	3	15
Sweet birch	0	0	17	8	6	31
Paper birch	0	0	10	0	1	11
Gray birch	0	2	1	0	0	3
Hickory	0	1	23	14	5	43
Beech	0	0	16	4	5	25
White ash	0	2	15	3	3	23
Black ash	0	0	1	0	0	1
Aspen	0	1	3	0	0	4
White oaks	0	1	17	4	2	24
Northern red oak	0	10	52	4	1	67
Other red oaks	0	2	33	4	0	39
Elm	0	0	1	0	0	1
Other hardwoods	0	0	1	4	3	8
All hardwoods	1	20	264	68	51	404
All species	1	23	275	80	86	465

Table 27.--Number of all-live sample trees (5.0+ inches d.b.h.) by major species and crown class, Northern Hardwoods forest-type type group.

Species	Crown class					All classes
	Open-grown	Dominant	Codominant	Intermediate	Suppressed	
Balsam fir	0	5	34	39	28	106
White spruce	0	0	1	4	4	9
Red spruce	1	3	36	14	18	72
White pine	1	2	31	9	22	65
Northern white-cedar	0	1	9	15	8	33
Hemlock	0	1	31	27	79	138
All softwoods	2	12	142	108	159	423
Red maple	2	24	300	56	17	399
Sugar maple	2	21	287	67	31	408
Yellow birch	0	7	136	21	8	172
Sweet birch	0	0	25	7	3	35
Paper birch	2	7	65	16	3	93
Gray birch	0	0	10	8	5	23
Hickory	0	0	11	1	0	12
Beech	0	9	106	33	24	172
White ash	1	5	69	17	4	96
Black ash	0	0	4	2	0	6
Aspen	0	12	24	1	0	37
Black cherry	0	0	13	2	0	15
White oaks	0	0	1	0	0	1
Northern red oak	0	1	36	2	2	41
Other red oaks	0	0	1	0	0	1
Elm	0	0	1	2	0	3
Other hardwoods	0	3	30	31	8	72
All hardwoods	7	89	1,119	266	105	1,586
All species	9	101	1,261	374	264	2,009

Table 28.--Number of all-live sample trees (5.0+ inches d.b.h.) by major species and crown class, other forest-type type groups.

Species	Crown class					All classes
	Open-grown	Dominant	Codominant	Intermediate	Suppressed	
Balsam fir	1	1	12	18	16	48
Tamarack	0	0	1	0	0	1
White spruce	0	0	0	4	0	4
Black spruce	0	0	0	1	0	1
Red spruce	0	0	8	4	9	21
Red pine	0	2	0	0	0	2
White pine	1	3	33	20	12	69
Northern white-cedar	0	0	1	1	1	3
Hemlock	0	0	2	1	5	8
All softwoods	2	6	57	49	43	157
Red maple	1	3	163	46	19	232
Sugar maple	0	0	13	6	1	20
Yellow birch	0	0	13	8	3	24
Sweet birch	0	0	0	2	1	3
Paper birch	0	9	77	8	4	98
Gray birch	0	1	1	0	0	2
Hickory	0	0	2	0	1	3
Beech	0	0	4	3	10	17
White ash	1	1	18	3	2	25
Aspen	0	11	30	8	2	51
Black cherry	0	0	7	4	1	12
White oaks	0	0	11	5	0	16
Northern red oak	0	1	43	7	3	54
Other red oaks	0	0	1	0	0	1
Elm	0	0	1	0	1	2
Other hardwoods	0	2	9	8	3	22
All hardwoods	2	28	393	108	51	582
All species	4	34	450	157	94	739

Table 29.--Number of open grown, dominant, and codominant sample trees by major species and dieback class, all forest-type groups.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	239	115	3	1	2	1	0	0	1	0	0	362
Tamarack	7	4	1	1	0	0	0	0	0	0	0	13
White spruce	30	10	0	0	0	0	0	0	0	0	0	40
Black spruce	16	7	1	0	0	0	0	0	0	0	0	24
Red spruce	277	175	7	5	0	0	1	0	0	0	0	465
Red pine	4	7	0	1	0	0	0	0	0	0	0	12
Pitch pine	0	1	0	2	1	0	0	0	0	0	0	4
White pine	268	245	11	1	3	0	0	1	0	0	0	529
Northern white-cedar	79	97	12	4	3	1	0	1	1	0	0	198
Hemlock	86	51	0	3	0	1	0	0	0	0	1	142
Other softwoods	3	0	0	0	0	0	0	0	0	0	0	3
All softwoods	1,009	712	35	18	9	3	1	2	2	0	1	1,792
Red maple	169	513	67	18	8	9	7	2	1	1	4	799
Sugar maple	107	236	14	6	1	2	1	0	0	0	1	368
Yellow birch	54	143	9	2	1	0	0	0	0	1	3	213
Sweet birch	23	29	1	0	0	0	0	0	0	0	0	53
Paper birch	43	208	29	4	4	1	0	0	1	0	3	293
Gray birch	2	20	3	2	1	0	0	0	0	0	0	28
Hickory	22	16	0	0	0	0	0	0	0	0	0	38
Beech	13	110	15	8	3	1	0	2	3	4	0	159
White ash	37	78	16	2	0	0	1	1	0	0	1	136
Black ash	2	4	2	2	0	0	3	2	0	0	0	15
Aspen	38	141	17	4	2	2	1	0	1	0	0	206
Black cherry	2	26	4	1	0	0	0	0	1	0	0	34
White oaks	4	24	5	1	1	0	0	0	0	0	0	35
Northern red oak	6	131	24	4	0	0	1	0	0	0	0	166
Other red oaks	4	45	3	0	0	0	0	0	0	0	0	52
Elm	2	2	0	1	0	0	0	1	0	0	0	6
Other hardwoods	10	41	5	2	1	0	0	0	0	1	0	60
All hardwoods	538	1,767	214	57	22	15	14	8	7	7	12	2,661
All species	1,547	2,479	249	75	31	18	15	10	9	7	13	4,453

Table 30.--Number of open grown, dominant, and codominant sample trees by major species and dieback class, White pine forest-type group.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	13	3	0	0	0	0	0	0	0	0	0	16
Tamarack	0	1	1	0	0	0	0	0	0	0	0	2
White spruce	6	0	0	0	0	0	0	0	0	0	0	6
Black spruce	0	1	0	0	0	0	0	0	0	0	0	1
Red spruce	27	16	0	0	0	0	0	0	0	0	0	43
Red pine	4	5	0	1	0	0	0	0	0	0	0	10
Pitch pine	0	1	0	2	1	0	0	0	0	0	0	4
White pine	214	206	6	1	0	0	0	0	0	0	0	427
Hemlock	61	27	0	0	0	0	0	0	0	0	0	88
Other softwoods	2	0	0	0	0	0	0	0	0	0	0	2
All softwoods	327	260	7	4	1	0	0	0	0	0	0	599
Red maple	22	60	11	3	0	0	1	0	0	0	0	97
Sugar maple	2	4	3	0	0	0	0	0	0	0	1	10
Yellow birch	3	8	1	0	0	0	0	0	0	0	0	12
Sweet birch	4	7	0	0	0	0	0	0	0	0	0	11
Paper birch	5	19	2	0	1	0	0	0	0	0	0	27
Gray birch	1	1	1	0	1	0	0	0	0	0	0	4
Hickory	0	1	0	0	0	0	0	0	0	0	0	1
Beech	5	3	1	0	1	0	0	0	0	0	0	10
White ash	6	12	1	0	0	0	0	0	0	0	0	19
Aspen	18	47	10	0	1	1	1	0	0	0	0	78
Black cherry	0	5	0	0	0	0	0	0	0	0	0	5
White oaks	1	3	1	0	0	0	0	0	0	0	0	5
Northern red oak	0	18	4	1	0	0	0	0	0	0	0	23
Other red oaks	0	14	1	0	0	0	0	0	0	0	0	15
Elm	0	1	0	0	0	0	0	1	0	0	0	2
Other hardwoods	0	1	0	0	0	0	0	0	0	0	0	1
All hardwoods	67	204	36	4	4	1	2	1	0	0	1	320
All species	394	464	43	8	5	1	2	1	0	0	1	919

Table 31.--Number of open grown, dominant, and codominant sample trees by major species and dieback class, Spruce/fir forest-type group.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	182	104	3	1	2	1	0	0	0	0	0	293
Tamarack	7	2	0	1	0	0	0	0	0	0	0	10
White spruce	23	10	0	0	0	0	0	0	0	0	0	33
Black spruce	16	6	1	0	0	0	0	0	0	0	0	23
Red spruce	223	140	6	5	0	0	0	0	0	0	0	374
White pine	9	7	2	0	1	0	0	0	0	0	0	19
Northern white-cedar	76	91	11	4	3	1	0	1	0	0	0	187
Hemlock	7	8	0	2	0	1	0	0	0	0	0	18
Other softwoods	1	0	0	0	0	0	0	0	0	0	0	1
All softwoods	544	368	23	13	6	3	0	1	0	0	0	958
Red maple	39	99	13	1	1	2	0	0	0	0	2	157
Sugar maple	6	13	0	0	0	0	0	0	0	0	0	19
Yellow birch	13	22	2	0	0	0	0	0	0	0	0	37
Paper birch	17	64	9	2	1	1	0	0	1	0	1	96
Gray birch	0	8	1	0	0	0	0	0	0	0	0	9
Beech	2	10	0	0	0	0	0	2	0	0	0	14
White ash	4	1	0	0	0	0	0	0	0	0	0	5
Black ash	2	3	1	2	0	0	2	0	0	0	0	10
Aspen	7	34	3	3	0	0	0	0	0	0	0	47
Black cherry	0	9	0	0	0	0	0	0	0	0	0	9
Elm	1	0	0	0	0	0	0	0	0	0	0	1
Other hardwoods	1	12	0	0	1	0	0	0	0	0	0	14
All hardwoods	92	275	29	8	3	3	2	2	1	0	3	418
All species	636	643	52	21	9	6	2	3	1	0	3	1,376

Table 32.--Number of open grown, dominant, and codominant sample trees by major species and dieback class, Oak/hickory forest-type group.

Species	Percent										All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
White pine	9	3	0	0	0	0	0	0	0	0	0	12
Hemlock	0	2	0	0	0	0	0	0	0	0	0	2
All softwoods	9	5	0	0	0	0	0	0	0	0	0	14
Red maple	6	42	3	0	1	0	0	0	0	0	0	52
Sugar maple	1	14	0	1	0	0	0	0	0	0	0	16
Yellow birch	5	3	0	0	0	0	0	0	0	0	0	8
Sweet birch	8	9	0	0	0	0	0	0	0	0	0	17
Paper birch	2	8	0	0	0	0	0	0	0	0	0	10
Gray birch	0	3	0	0	0	0	0	0	0	0	0	3
Hickory	11	13	0	0	0	0	0	0	0	0	0	24
Beech	1	14	1	0	0	0	0	0	0	0	0	16
White ash	3	11	1	1	0	0	1	0	0	0	0	17
Black ash	0	0	1	0	0	0	0	0	0	0	0	1
Aspen	1	3	0	0	0	0	0	0	0	0	0	4
White oaks	3	14	1	0	0	0	0	0	0	0	0	18
Northern red oak	3	52	5	2	0	0	0	0	0	0	0	62
Other red oaks	4	29	2	0	0	0	0	0	0	0	0	35
Elm	1	0	0	0	0	0	0	0	0	0	0	1
Other hardwoods	0	1	0	0	0	0	0	0	0	0	0	1
All hardwoods	49	216	14	4	1	0	1	0	0	0	0	285
All species	58	221	14	4	1	0	1	0	0	0	0	299

Table 33.--Number of open grown, dominant, and codominant sample trees by major species and dieback class, Northern Hardwoods forest-type group.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	32	6	0	0	0	0	0	0	1	0	0	39
White spruce	1	0	0	0	0	0	0	0	0	0	0	1
Red spruce	25	13	1	0	0	0	1	0	0	0	0	40
White pine	18	11	3	0	1	0	0	1	0	0	0	34
Northern white-cedar	3	5	1	0	0	0	0	0	1	0	0	10
Hemlock	18	12	0	1	0	0	0	0	0	0	1	32
All softwoods	97	47	5	1	1	0	1	1	2	0	1	156
Red maple	75	196	26	8	5	6	6	1	0	1	2	326
Sugar maple	96	197	9	5	1	2	0	0	0	0	0	310
Yellow birch	33	98	5	2	1	0	0	0	0	1	3	143
Sweet birch	11	13	1	0	0	0	0	0	0	0	0	25
Paper birch	9	55	7	0	1	0	0	0	0	0	2	74
Gray birch	1	6	1	2	0	0	0	0	0	0	0	10
Hickory	9	2	0	0	0	0	0	0	0	0	0	11
Beech	5	79	13	8	2	1	0	0	3	4	0	115
White ash	18	46	9	1	0	0	0	0	0	0	1	75
Black ash	0	1	0	0	0	0	1	2	0	0	0	4
Aspen	5	24	3	1	1	1	0	0	1	0	0	36
Black cherry	1	8	2	1	0	0	0	0	1	0	0	13
White oaks	0	1	0	0	0	0	0	0	0	0	0	1
Northern red oak	2	19	14	1	0	0	1	0	0	0	0	37
Other red oaks	0	1	0	0	0	0	0	0	0	0	0	1
Elm	0	0	0	1	0	0	0	0	0	0	0	1
Other hardwoods	3	22	5	2	0	0	0	0	0	1	0	33
All hardwoods	268	768	95	32	11	10	8	3	5	7	8	1,215
All species	365	815	100	33	12	10	9	4	7	7	9	1,371

Table 34.--Number of open grown, dominant, and codominant sample trees by species and dieback class, other forest-type groups.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	12	2	0	0	0	0	0	0	0	0	0	14
Tamarack	0	1	0	0	0	0	0	0	0	0	0	1
Red spruce	2	6	0	0	0	0	0	0	0	0	0	8
Red pine	0	2	0	0	0	0	0	0	0	0	0	2
White pine	18	18	0	0	1	0	0	0	0	0	0	37
Northern white-cedar	0	1	0	0	0	0	0	0	0	0	0	1
Hemlock	0	2	0	0	0	0	0	0	0	0	0	2
All softwoods	32	32	0	0	1	0	0	0	0	0	0	65
Red maple	27	116	14	6	1	1	0	1	1	0	0	167
Sugar maple	2	8	2	0	0	0	1	0	0	0	0	13
Yellow birch	0	12	1	0	0	0	0	0	0	0	0	13
Paper birch	10	62	11	2	1	0	0	0	0	0	0	86
Gray birch	0	2	0	0	0	0	0	0	0	0	0	2
Hickory	2	0	0	0	0	0	0	0	0	0	0	2
Beech	0	4	0	0	0	0	0	0	0	0	0	4
White ash	6	8	5	0	0	0	0	1	0	0	0	20
Aspen	7	33	1	0	0	0	0	0	0	0	0	41
Black cherry	1	4	2	0	0	0	0	0	0	0	0	7
White oaks	0	6	3	1	1	0	0	0	0	0	0	11
Northern red oak	1	42	1	0	0	0	0	0	0	0	0	44
Other red oaks	0	1	0	0	0	0	0	0	0	0	0	1
Elm	0	1	0	0	0	0	0	0	0	0	0	1
Other hardwoods	6	5	0	0	0	0	0	0	0	0	0	11
All hardwoods	62	304	40	9	3	1	1	2	1	0	0	423
All species	94	336	40	9	4	1	1	2	1	0	0	488

Table 35.--Number of open grown, dominant, and codominant sample trees by major species and transparency class, all forest-type groups.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	0	183	155	23	1	0	0	0	0	0	0	362
Tamarack	0	1	9	2	1	0	0	0	0	0	0	13
White spruce	0	16	20	4	0	0	0	0	0	0	0	40
Black spruce	0	17	7	0	0	0	0	0	0	0	0	24
Red spruce	1	197	216	50	1	0	0	0	0	0	0	465
Red pine	0	7	3	1	0	1	0	0	0	0	0	12
Pitch pine	0	0	0	2	2	0	0	0	0	0	0	4
White pine	0	110	291	104	20	4	0	0	0	0	0	529
Northern white-cedar	0	24	99	59	13	2	0	0	1	0	0	198
Hemlock	0	40	86	13	3	0	0	0	0	0	0	142
Other softwoods	0	2	1	0	0	0	0	0	0	0	0	3
All softwoods	1	597	887	258	41	7	0	0	1	0	0	1,792
Red maple	3	282	393	86	23	5	3	1	0	2	1	799
Sugar maple	27	123	182	32	3	0	1	0	0	0	0	368
Yellow birch	8	105	82	10	4	0	0	1	0	1	2	213
Sweet birch	0	33	18	2	0	0	0	0	0	0	0	53
Paper birch	0	50	171	51	15	4	0	0	0	0	2	293
Gray birch	1	4	10	10	3	0	0	0	0	0	0	28
Hickory	0	31	7	0	0	0	0	0	0	0	0	38
Beech	0	29	75	34	6	5	1	2	0	1	6	159
White ash	0	29	75	25	6	1	0	0	0	0	0	136
Black ash	0	1	13	1	0	0	0	0	0	0	0	15
Aspen	1	29	102	56	11	3	3	0	1	0	0	206
Black cherry	0	2	22	7	0	1	1	1	0	0	0	34
White oaks	0	26	6	3	0	0	0	0	0	0	0	35
Northern red oak	0	69	66	15	5	3	0	1	0	5	2	166
Other red oaks	0	18	22	10	2	0	0	0	0	0	0	52
Elm	0	1	3	1	0	0	1	0	0	0	0	6
Other hardwoods	0	19	31	7	0	3	0	0	0	0	0	60
All hardwoods	40	851	1,278	350	78	25	10	6	1	9	13	2,661
All species	41	1,448	2,165	608	119	32	10	6	2	9	13	4,453

Table 36.--Number of open grown, dominant, and codominant sample trees by major species and transparency class, White pine forest-type group.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	0	11	5	0	0	0	0	0	0	0	0	16
Tamarack	0	0	0	1	1	0	0	0	0	0	0	2
White spruce	0	0	6	0	0	0	0	0	0	0	0	6
Black spruce	0	1	0	0	0	0	0	0	0	0	0	1
Red spruce	0	18	22	3	0	0	0	0	0	0	0	43
Red pine	0	6	2	1	0	1	0	0	0	0	0	10
Pitch pine	0	0	0	2	2	0	0	0	0	0	0	4
White pine	0	100	242	75	10	0	0	0	0	0	0	427
Hemlock	0	24	53	9	2	0	0	0	0	0	0	88
Other softwoods	0	2	0	0	0	0	0	0	0	0	0	2
All softwoods	0	162	330	91	15	1	0	0	0	0	0	599
Red maple	0	46	40	6	4	1	0	0	0	0	0	97
Sugar maple	0	4	3	3	0	0	0	0	0	0	0	10
Yellow birch	0	6	5	1	0	0	0	0	0	0	0	12
Sweet birch	0	6	5	0	0	0	0	0	0	0	0	11
Paper birch	0	7	15	2	1	2	0	0	0	0	0	27
Gray birch	0	2	1	0	1	0	0	0	0	0	0	4
Hickory	0	1	0	0	0	0	0	0	0	0	0	1
Beech	0	6	1	3	0	0	0	0	0	0	0	10
White ash	0	8	10	1	0	0	0	0	0	0	0	19
Aspen	0	15	42	15	4	2	0	0	0	0	0	78
Black cherry	0	0	4	1	0	0	0	0	0	0	0	5
White oaks	0	4	0	1	0	0	0	0	0	0	0	5
Northern red oak	0	7	13	2	1	0	0	0	0	0	0	23
Other red oaks	0	8	6	0	1	0	0	0	0	0	0	15
Elm	0	1	0	1	0	0	0	0	0	0	0	2
Other hardwoods	0	1	0	0	0	0	0	0	0	0	0	1
All hardwoods	0	122	145	36	12	5	0	0	0	0	0	320
All species	0	284	475	127	27	6	0	0	0	0	0	919

Table 37.--Number of open grown, dominant, and codominant sample trees by major species and transparency class, Spruce/fir forest-type group.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	0	140	134	19	0	0	0	0	0	0	0	293
Tamarack	0	1	8	1	0	0	0	0	0	0	0	10
White spruce	0	15	14	4	0	0	0	0	0	0	0	33
Black spruce	0	16	7	0	0	0	0	0	0	0	0	23
Red spruce	1	148	180	44	1	0	0	0	0	0	0	374
White pine	0	1	13	4	0	1	0	0	0	0	0	19
Northern white-cedar	0	22	95	55	13	1	0	0	1	0	0	187
Hemlock	0	6	9	2	1	0	0	0	0	0	0	18
Other softwoods	0	0	1	0	0	0	0	0	0	0	0	1
All softwoods	1	349	461	129	15	2	0	0	1	0	0	958
Red maple	0	41	87	23	5	1	0	0	0	0	0	157
Sugar maple	0	10	9	0	0	0	0	0	0	0	0	19
Yellow birch	0	20	17	0	0	0	0	0	0	0	0	37
Paper birch	0	10	59	19	5	2	0	0	0	0	1	96
Gray birch	1	0	1	6	1	0	0	0	0	0	0	9
Beech	0	1	10	1	0	2	0	0	0	0	0	14
White ash	0	0	5	0	0	0	0	0	0	0	0	5
Black ash	0	0	10	0	0	0	0	0	0	0	0	10
Aspen	0	3	27	17	0	0	0	0	0	0	0	47
Black cherry	0	0	6	3	0	0	0	0	0	0	0	9
Elm	0	0	1	0	0	0	0	0	0	0	0	1
Other hardwoods	0	3	9	2	0	0	0	0	0	0	0	14
All hardwoods	1	88	241	71	11	5	0	0	0	0	1	418
All species	2	437	702	200	26	7	0	0	1	0	1	1,376

Table 38.--Number of open grown, dominant, and codominant sample trees by major species and transparency class, Oak/hickory forest-type group.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
White pine	0	3	6	2	0	1	0	0	0	0	0	12
Hemlock	0	0	2	0	0	0	0	0	0	0	0	2
All softwoods	0	3	8	2	0	1	0	0	0	0	0	14
Red maple	0	25	24	2	1	0	0	0	0	0	0	52
Sugar maple	0	13	3	0	0	0	0	0	0	0	0	16
Yellow birch	0	3	5	0	0	0	0	0	0	0	0	8
Sweet birch	0	13	3	1	0	0	0	0	0	0	0	17
Paper birch	0	1	6	3	0	0	0	0	0	0	0	10
Gray birch	0	0	3	0	0	0	0	0	0	0	0	3
Hickory	0	19	5	0	0	0	0	0	0	0	0	24
Beech	0	4	6	0	0	0	0	0	0	1	5	16
White ash	0	3	11	2	1	0	0	0	0	0	0	17
Black ash	0	0	1	0	0	0	0	0	0	0	0	1
Aspen	0	1	1	1	0	0	1	0	0	0	0	4
White oaks	0	14	3	1	0	0	0	0	0	0	0	18
Northern red oak	0	31	17	4	3	3	0	0	0	3	1	62
Other red oaks	0	10	14	10	1	0	0	0	0	0	0	35
Elm	0	0	1	0	0	0	0	0	0	0	0	1
Other hardwoods	0	1	0	0	0	0	0	0	0	0	0	1
All hardwoods	0	138	103	24	6	3	1	0	0	4	6	285
All species	0	141	111	26	6	4	1	0	0	4	6	299

Table 39.--Number of open grown, dominant, and codominant sample trees by major species and transparency class, Northern Hardwoods forest-type group.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	0	31	6	1	1	0	0	0	0	0	0	39
White spruce	0	1	0	0	0	0	0	0	0	0	0	1
Red spruce	0	27	10	3	0	0	0	0	0	0	0	40
White pine	0	1	8	15	8	2	0	0	0	0	0	34
Northern white-cedar	0	2	3	4	0	1	0	0	0	0	0	10
Hemlock	0	8	22	2	0	0	0	0	0	0	0	32
All softwoods	0	70	49	25	9	3	0	0	0	0	0	156
Red maple	3	129	148	35	8	0	1	1	0	0	1	326
Sugar maple	27	96	157	27	3	0	0	0	0	0	0	310
Yellow birch	8	71	48	8	4	0	0	1	0	1	2	143
Sweet birch	0	14	10	1	0	0	0	0	0	0	0	25
Paper birch	0	20	35	15	3	0	0	0	0	0	1	74
Gray birch	0	1	5	3	1	0	0	0	0	0	0	10
Hickory	0	9	2	0	0	0	0	0	0	0	0	11
Beech	0	17	55	30	6	3	1	2	0	0	1	115
White ash	0	16	39	16	3	1	0	0	0	0	0	75
Black ash	0	1	2	1	0	0	0	0	0	0	0	4
Aspen	1	3	14	11	4	1	1	0	1	0	0	36
Black cherry	0	2	7	1	0	1	1	1	0	0	0	13
White oaks	0	0	1	0	0	0	0	0	0	0	0	1
Northern red oak	0	5	18	9	1	0	0	1	0	2	1	37
Other red oaks	0	0	1	0	0	0	0	0	0	0	0	1
Elm	0	0	0	0	0	0	1	0	0	0	0	1
Other hardwoods	0	9	18	3	0	3	0	0	0	0	0	33
All hardwoods	39	393	560	160	33	9	5	6	1	3	6	1,215
All species	39	463	609	185	42	12	5	6	1	3	6	1,371

Table 40.--Number of open grown, dominant, and codominant sample trees by major species and transparency class, other forest-type groups.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	0	1	10	3	0	0	0	0	0	0	0	14
Tamarack	0	0	1	0	0	0	0	0	0	0	0	1
Red spruce	0	4	4	0	0	0	0	0	0	0	0	8
Red pine	0	1	1	0	0	0	0	0	0	0	0	2
White pine	0	5	22	8	2	0	0	0	0	0	0	37
Northern white-cedar	0	0	1	0	0	0	0	0	0	0	0	1
Hemlock	0	2	0	0	0	0	0	0	0	0	0	2
All softwoods	0	13	39	11	2	0	0	0	0	0	0	65
Red maple	0	41	94	20	5	3	2	0	0	2	0	167
Sugar maple	0	0	10	2	0	0	1	0	0	0	0	13
Yellow birch	0	5	7	1	0	0	0	0	0	0	0	13
Paper birch	0	12	56	12	6	0	0	0	0	0	0	86
Gray birch	0	1	0	1	0	0	0	0	0	0	0	2
Hickory	0	2	0	0	0	0	0	0	0	0	0	2
Beech	0	1	3	0	0	0	0	0	0	0	0	4
White ash	0	2	10	6	2	0	0	0	0	0	0	20
Aspen	0	7	18	12	3	0	1	0	0	0	0	41
Black cherry	0	0	5	2	0	0	0	0	0	0	0	7
White oaks	0	8	2	1	0	0	0	0	0	0	0	11
Northern red oak	0	26	18	0	0	0	0	0	0	0	0	44
Other red oaks	0	0	1	0	0	0	0	0	0	0	0	1
Elm	0	0	1	0	0	0	0	0	0	0	0	1
Other hardwoods	0	5	4	2	0	0	0	0	0	0	0	11
All hardwoods	0	110	229	59	16	3	4	0	0	2	0	423
All species	0	123	268	70	18	3	4	0	0	2	0	488

Table 41.--Number of open grown, dominant, and codominant sample trees by major species and discoloration class, all forest-type groups.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	152	207	2	1	0	0	0	0	0	0	0	362
Tamarack	13	0	0	0	0	0	0	0	0	0	0	13
White spruce	37	3	0	0	0	0	0	0	0	0	0	40
Black spruce	24	0	0	0	0	0	0	0	0	0	0	24
Red spruce	391	74	0	0	0	0	0	0	0	0	0	465
Red pine	7	5	0	0	0	0	0	0	0	0	0	12
Pitch pine	0	3	1	0	0	0	0	0	0	0	0	4
White pine	280	246	1	1	0	1	0	0	0	0	0	529
Northern white-cedar	114	83	1	0	0	0	0	0	0	0	0	198
Hemlock	112	30	0	0	0	0	0	0	0	0	0	142
Other softwoods	3	0	0	0	0	0	0	0	0	0	0	3
All softwoods	1,133	651	5	2	0	1	0	0	0	0	0	1,792
Red maple	594	198	4	1	0	0	0	0	0	0	2	799
Sugar maple	263	103	2	0	0	0	0	0	0	0	0	368
Yellow birch	165	48	0	0	0	0	0	0	0	0	0	213
Sweet birch	43	10	0	0	0	0	0	0	0	0	0	53
Paper birch	210	83	0	0	0	0	0	0	0	0	0	293
Gray birch	19	9	0	0	0	0	0	0	0	0	0	28
Hickory	35	3	0	0	0	0	0	0	0	0	0	38
Beech	109	46	0	0	0	1	1	0	0	2	0	159
White ash	127	9	0	0	0	0	0	0	0	0	0	136
Black ash	12	3	0	0	0	0	0	0	0	0	0	15
Aspen	178	26	1	0	0	0	0	0	0	0	1	206
Black cherry	27	7	0	0	0	0	0	0	0	0	0	34
White oaks	23	12	0	0	0	0	0	0	0	0	0	35
Northern red oak	126	37	0	0	0	0	0	0	0	1	2	166
Other red oaks	45	6	1	0	0	0	0	0	0	0	0	52
Elm	5	1	0	0	0	0	0	0	0	0	0	6
Other hardwoods	42	15	3	0	0	0	0	0	0	0	0	60
All hardwoods	2,023	616	11	1	0	1	1	0	0	3	5	2,661
All species	3,156	1,267	16	3	0	2	1	0	0	3	5	4,453

Table 42.--Number of open grown, dominant, and codominant sample trees by major species and discoloration class, White pine forest-type group.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	10	6	0	0	0	0	0	0	0	0	0	16
Tamarack	2	0	0	0	0	0	0	0	0	0	0	2
White spruce	6	0	0	0	0	0	0	0	0	0	0	6
Black spruce	1	0	0	0	0	0	0	0	0	0	0	1
Red spruce	41	2	0	0	0	0	0	0	0	0	0	43
Red pine	6	4	0	0	0	0	0	0	0	0	0	10
Pitch pine	0	3	1	0	0	0	0	0	0	0	0	4
White pine	209	216	0	1	0	1	0	0	0	0	0	427
Hemlock	64	24	0	0	0	0	0	0	0	0	0	88
Other softwoods	2	0	0	0	0	0	0	0	0	0	0	2
All softwoods	341	255	1	1	0	1	0	0	0	0	0	599
Red maple	78	19	0	0	0	0	0	0	0	0	0	97
Sugar maple	6	3	1	0	0	0	0	0	0	0	0	10
Yellow birch	10	2	0	0	0	0	0	0	0	0	0	12
Sweet birch	8	3	0	0	0	0	0	0	0	0	0	11
Paper birch	19	8	0	0	0	0	0	0	0	0	0	27
Gray birch	3	1	0	0	0	0	0	0	0	0	0	4
Hickory	1	0	0	0	0	0	0	0	0	0	0	1
Beech	10	0	0	0	0	0	0	0	0	0	0	10
White ash	15	4	0	0	0	0	0	0	0	0	0	19
Aspen	71	5	1	0	0	0	0	0	0	0	1	78
Black cherry	4	1	0	0	0	0	0	0	0	0	0	5
White oaks	5	0	0	0	0	0	0	0	0	0	0	5
Northern red oak	19	4	0	0	0	0	0	0	0	0	0	23
Other red oaks	14	1	0	0	0	0	0	0	0	0	0	15
Elm	2	0	0	0	0	0	0	0	0	0	0	2
Other hardwoods	1	0	0	0	0	0	0	0	0	0	0	1
All hardwoods	266	51	2	0	0	0	0	0	0	0	1	320
All species	607	306	3	1	0	1	0	0	0	0	1	919

Table 43.--Number of open grown, dominant, and codominant sample trees by major species and discoloration class, Spruce/fir forest-type group.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	118	173	1	1	0	0	0	0	0	0	0	293
Tamarack	10	0	0	0	0	0	0	0	0	0	0	10
White spruce	30	3	0	0	0	0	0	0	0	0	0	33
Black spruce	23	0	0	0	0	0	0	0	0	0	0	23
Red spruce	308	66	0	0	0	0	0	0	0	0	0	374
White pine	15	4	0	0	0	0	0	0	0	0	0	19
Northern white-cedar	108	79	0	0	0	0	0	0	0	0	0	187
Hemlock	18	0	0	0	0	0	0	0	0	0	0	18
Other softwoods	1	0	0	0	0	0	0	0	0	0	0	1
All softwoods	631	325	1	1	0	0	0	0	0	0	0	958
Red maple	115	42	0	0	0	0	0	0	0	0	0	157
Sugar maple	14	5	0	0	0	0	0	0	0	0	0	19
Yellow birch	29	8	0	0	0	0	0	0	0	0	0	37
Paper birch	66	30	0	0	0	0	0	0	0	0	0	96
Gray birch	6	3	0	0	0	0	0	0	0	0	0	9
Beech	12	1	0	0	0	0	0	0	0	1	0	14
White ash	5	0	0	0	0	0	0	0	0	0	0	5
Black ash	7	3	0	0	0	0	0	0	0	0	0	10
Aspen	37	10	0	0	0	0	0	0	0	0	0	47
Black cherry	8	1	0	0	0	0	0	0	0	0	0	9
Elm	1	0	0	0	0	0	0	0	0	0	0	1
Other hardwoods	14	0	0	0	0	0	0	0	0	0	0	14
All hardwoods	314	103	0	0	0	0	0	0	0	1	0	418
All species	945	428	1	1	0	0	0	0	0	1	0	1,376

Table 44.--Number of open grown, dominant, and codominant sample trees by major species and discoloration class, Oak/hickory forest-type group.

Species	Percent										All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
White pine	9	3	0	0	0	0	0	0	0	0	0	12
Hemlock	2	0	0	0	0	0	0	0	0	0	0	2
All softwoods	11	3	0	0	0	0	0	0	0	0	0	14
Red maple	47	5	0	0	0	0	0	0	0	0	0	52
Sugar maple	15	1	0	0	0	0	0	0	0	0	0	16
Yellow birch	7	1	0	0	0	0	0	0	0	0	0	8
Sweet birch	15	2	0	0	0	0	0	0	0	0	0	17
Paper birch	6	4	0	0	0	0	0	0	0	0	0	10
Gray birch	3	0	0	0	0	0	0	0	0	0	0	3
Hickory	22	2	0	0	0	0	0	0	0	0	0	24
Beech	14	2	0	0	0	0	0	0	0	0	0	16
White ash	16	1	0	0	0	0	0	0	0	0	0	17
Black ash	1	0	0	0	0	0	0	0	0	0	0	1
Aspen	3	1	0	0	0	0	0	0	0	0	0	4
White oaks	12	6	0	0	0	0	0	0	0	0	0	18
Northern red oak	49	11	0	0	0	0	0	0	0	0	2	62
Other red oaks	30	5	0	0	0	0	0	0	0	0	0	35
Elm	1	0	0	0	0	0	0	0	0	0	0	1
Other hardwoods	0	1	0	0	0	0	0	0	0	0	0	1
All hardwoods	241	42	0	0	0	0	0	0	0	0	2	285
All species	252	45	0	0	0	0	0	0	0	0	2	299

Table 45.--Number of open grown, dominant, and codominant sample trees by major species and discoloration class, Northern Hardwoods forest-type group.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	19	19	1	0	0	0	0	0	0	0	0	39
White spruce	1	0	0	0	0	0	0	0	0	0	0	1
Red spruce	36	4	0	0	0	0	0	0	0	0	0	40
White pine	25	9	0	0	0	0	0	0	0	0	0	34
Northern white-cedar	5	4	1	0	0	0	0	0	0	0	0	10
Hemlock	26	6	0	0	0	0	0	0	0	0	0	32
All softwoods	112	42	2	0	0	0	0	0	0	0	0	156
Red maple	231	88	4	1	0	0	0	0	0	0	2	326
Sugar maple	218	91	1	0	0	0	0	0	0	0	0	310
Yellow birch	108	35	0	0	0	0	0	0	0	0	0	143
Sweet birch	20	5	0	0	0	0	0	0	0	0	0	25
Paper birch	45	29	0	0	0	0	0	0	0	0	0	74
Gray birch	6	4	0	0	0	0	0	0	0	0	0	10
Hickory	10	1	0	0	0	0	0	0	0	0	0	11
Beech	70	42	0	0	0	1	1	0	0	1	0	115
White ash	72	3	0	0	0	0	0	0	0	0	0	75
Black ash	4	0	0	0	0	0	0	0	0	0	0	4
Aspen	28	8	0	0	0	0	0	0	0	0	0	36
Black cherry	11	2	0	0	0	0	0	0	0	0	0	13
White oaks	0	1	0	0	0	0	0	0	0	0	0	1
Northern red oak	23	13	0	0	0	0	0	0	0	1	0	37
Other red oaks	0	0	1	0	0	0	0	0	0	0	0	1
Elm	0	1	0	0	0	0	0	0	0	0	0	1
Other hardwoods	18	12	3	0	0	0	0	0	0	0	0	33
All hardwoods	864	335	9	1	0	1	1	0	0	2	2	1,215
All species	976	377	11	1	0	1	1	0	0	2	2	1,371

Table 46.--Number of open grown, dominant, and codominant sample trees by major species and discoloration class, other forest-type groups.

Species	Percent											All classes
	None	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-99	
Balsam fir	5	9	0	0	0	0	0	0	0	0	0	14
Tamarack	1	0	0	0	0	0	0	0	0	0	0	1
Red spruce	6	2	0	0	0	0	0	0	0	0	0	8
Red pine	1	1	0	0	0	0	0	0	0	0	0	2
White pine	22	14	1	0	0	0	0	0	0	0	0	37
Northern white-cedar	1	0	0	0	0	0	0	0	0	0	0	1
Hemlock	2	0	0	0	0	0	0	0	0	0	0	2
All softwoods	38	26	1	0	0	0	0	0	0	0	0	65
Red maple	123	44	0	0	0	0	0	0	0	0	0	167
Sugar maple	10	3	0	0	0	0	0	0	0	0	0	13
Yellow birch	11	2	0	0	0	0	0	0	0	0	0	13
Paper birch	74	12	0	0	0	0	0	0	0	0	0	86
Gray birch	1	1	0	0	0	0	0	0	0	0	0	2
Hickory	2	0	0	0	0	0	0	0	0	0	0	2
Beech	3	1	0	0	0	0	0	0	0	0	0	4
White ash	19	1	0	0	0	0	0	0	0	0	0	20
Aspen	39	2	0	0	0	0	0	0	0	0	0	41
Black cherry	4	3	0	0	0	0	0	0	0	0	0	7
White oaks	6	5	0	0	0	0	0	0	0	0	0	11
Northern red oak	35	9	0	0	0	0	0	0	0	0	0	44
Other red oaks	1	0	0	0	0	0	0	0	0	0	0	1
Elm	1	0	0	0	0	0	0	0	0	0	0	1
Other hardwoods	9	2	0	0	0	0	0	0	0	0	0	11
All hardwoods	338	85	0	0	0	0	0	0	0	0	0	423
All species	376	111	1	0	0	0	0	0	0	0	0	488

Table 47.--Number of open grown, dominant, and codominant sample trees by major species and years of needle retention, all forest-type groups.

Species	years								All years
	1	2	3	4	5	6	7	8+	
Balsam fir	0	3	7	18	113	117	77	27	362
Norway spruce	0	0	0	1	1	0	0	0	2
White spruce	0	0	0	2	8	11	15	4	40
Black spruce	0	0	1	4	6	3	8	2	24
Blue spruce	0	0	0	0	1	0	0	0	1
Red spruce	0	0	4	10	69	157	120	105	465
Red pine	4	4	4	0	0	0	0	0	12
Pitch pine	0	3	1	0	0	0	0	0	4
Eastern white pine	143	245	134	4	0	0	2	1	529
Total	147	255	151	39	198	288	222	139	1,439

Table 48.--Number of open grown, dominant, and codominant sample trees by major species and years of needle retention, White pine forest-type group.

Species	years								All years
	1	2	3	4	5	6	7	8+	
Balsam fir	0	0	0	0	2	8	6	0	16
Norway spruce	0	0	0	1	1	0	0	0	2
White spruce	0	0	0	0	2	1	3	0	6
Black spruce	0	0	0	0	1	0	0	0	1
Red spruce	0	0	0	0	3	1	15	24	43
Red pine	4	4	2	0	0	0	0	0	10
Pitch pine	0	3	1	0	0	0	0	0	4
Eastern white pine	100	207	120	0	0	0	0	0	427
Total	104	214	123	1	9	10	24	24	509

Table 49.--Number of open grown, dominant, and codominant sample trees by major species and years of needle retention, Spruce/fir forest-type group.

Species	years								All years
	1	2	3	4	5	6	7	8+	
Balsam fir	0	3	5	17	96	91	61	20	293
White spruce	0	0	0	2	6	10	12	3	33
Black spruce	0	0	1	4	5	3	8	2	23
Blue spruce	0	0	0	0	1	0	0	0	1
Red spruce	0	0	2	9	52	143	96	72	374
Eastern white pine	2	6	7	3	0	0	0	1	19
Total	2	9	15	35	160	247	177	98	743

Table 50.--Number of open grown, dominant, and codominant sample trees by major species and years of needle retention, Oak/hickory forest-type group.

Species	years								All years
	1	2	3	4	5	6	7	8+	
Eastern white pine	8	3	0	1	0	0	0	0	12
Total	8	3	0	1	0	0	0	0	12

Table 51.--Number of open grown, dominant, and codominant sample trees by major species and years of needle retention, Northern Hardwoods forest-type group.

Species	years								All years
	1	2	3	4	5	6	7	8+	
Balsam fir	0	0	1	0	11	14	8	5	39
White spruce	0	0	0	0	0	0	0	1	1
Red spruce	0	0	2	1	13	12	6	6	40
Eastern white pine	15	13	6	0	0	0	0	0	34
Total	15	13	9	1	24	26	14	12	114

Table 52.--Number of open grown, dominant, and codominant sample trees by major species and years of needle retention, other forest-type groups.

Species	years								All
	1	2	3	4	5	6	7	8+	years
Balsam fir	0	0	1	1	4	4	2	2	14
Red spruce	0	0	0	0	1	1	3	3	8
Red pine	0	0	2	0	0	0	0	0	2
Eastern white pine	18	16	1	0	0	0	2	0	37
Total	18	16	4	1	5	5	7	5	61

Table 53.--Number of plots by atmospheric pollutant, occurrence of pollution symptoms, and state or region.

Indicator & symptoms	States				All states
	Maine	New Hampshire	Vermont	S. New England	
All plots	117	33	24	30	204
No. of plots any indicator	112	29	23	28	192
O_3 species recorded	47	27	21	28	123
O_3 symptoms noted	0	6	1	11	18
SO_2 species recorded	99	22	21	10	152
SO_2 symptoms noted	6	0	0	0	6
HF species recorded	103	26	14	15	158

Brooks, Robert T.; Dickson, David R.; Burkman, William B.; Millers, Imants; Miller-Weeks, Margaret; Cooter, Ellen; Smith, Luther. 1992. **Forest health monitoring in New England: 1990 annual report.** Resour. Bull. NE-125. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 111 p.

The USDA Forest Service, in cooperation with the U.S. Environmental Protection Agency and the New England State Forestry Agencies initiated field sampling for the Forest Health Monitoring program in 1990. Two hundred and sixty-three permanent sample plots were established. Measurements were taken to characterize the physical conditions of the plots. This publication reports results of the first-year measurements of tree crown condition, tree damage, and bioindicator plants. The publication also reports the status of major forest stressors during 1990, including forest insects and pathogens, atmospheric deposition and pollution, and climate and weather.

Headquarters of the Northeastern Forest Experiment Station is in Radnor, Pennsylvania. Field laboratories are maintained at:

Amherst, Massachusetts, in cooperation with the University of Massachusetts

Burlington, Vermont, in cooperation with the University of Vermont

Delaware, Ohio

Durham, New Hampshire, in cooperation with the University of New Hampshire

Hamden, Connecticut, in cooperation with Yale University

Morgantown, West Virginia, in cooperation with West Virginia University

Orono, Maine, in cooperation with the University of Maine

Parsons, West Virginia

Princeton, West Virginia

Syracuse, New York, in cooperation with the State University of New York, College of Environmental Sciences and Forestry at Syracuse University

University Park, Pennsylvania, in cooperation with The Pennsylvania State University

Warren, Pennsylvania

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